GENI

Exploring Networks of the Future

Aaron Falk

March 31, 2009

www.geni.net

Sponsored by the National Science Foundation

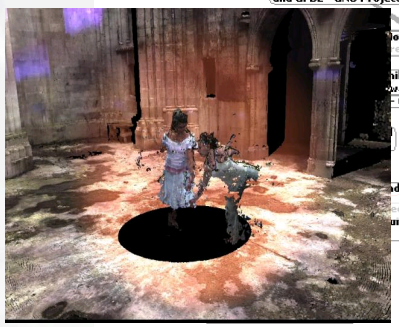
Outline

- What is GENI?
- How we'll build it, how we'll use it (Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

Global networks are rapidly transforming societies and economies

Increasing social and economic reliance on the Internet

- Social networking
- Banking and finance
- Online stores and commerce
- Shared virtual worlds



Credit: MONET Group at UIUC

Society-changing innovations

- Peer to peer
- Cloud computing
- Location-aware services
- Explosion of data-intensive applications
- Ubiquitous sensor networks

Worrying trends

- Increasing security breaches
- Rapidly eroding privacy
- Potential for large-scale failures

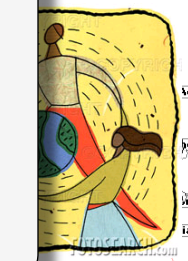
Global networks are creating extremely important new challenges

Science Issues

We cannot currently understand or predict the behavior of complex, large-scale networks

Innovation Issues

Substantial barriers to at-scale experimentation with new architectures, services, and technologies



Society Issues

We increasingly rely on the Internet but are unsure that can trust its security, privacy or resilience

Network Science & Engineering (NetSE)

Science → Understand the complexity of large-scale networks → Network science and engineering researchers

- Understand emergent behaviors, local-global interactions, system failures and/or degradations
- Develop models that accurately predict and control network behaviors

Technology → Develop new architectures, exploiting new substrates → Distributed systems and substrate researchers

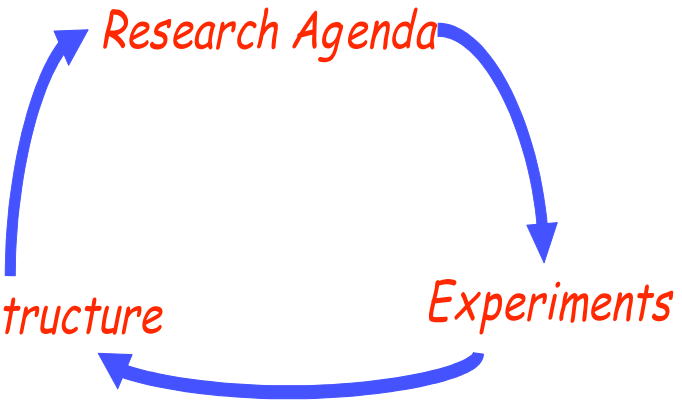
- Develop architectures for self-evolving, robust, manageable future networks
- Develop design principles for seamless mobility support
- Leverage optical and wireless substrates for reliability and performance
- Understand the fundamental potential and limitations of technology

Society → Enable new applications and new economies, while ensuring security and privacy → Security, privacy, economics, AI, social science researchers

- Design secure, survivable, persistent systems, especially when under attack
- Understand technical, economic and legal design trade-offs, enable privacy protection
- Explore AI-inspired and game-theoretic paradigms for resource and performance optimization

Research Agenda / Experiments / Infrastructure

- Research agenda
  - Identifies fundamental questions
  - Drives a set of experiments to validate theories and models
- Experiments & requirements
  - Drives what infrastructure and facilities are needed



- Infrastructure could range from
  - Existing Internet, existing testbeds, federation of testbeds, something brand new (from small to large), federation of all of the above, to federation with international efforts
  - No pre-ordained outcome

Existing Input

- Clark et al. planning document for Global Environment for Network Innovations
- Shenker et al. "I Dream of GENI" document
- Kearns and Forrest ISAT study
- Feigenbaum, Mitzenmacher, and others on Theory of Networked Computation
- Hendler and others in Web Science
- Ruzena Bajcsy, Fran Berman, and others on CS-plus-Social Sciences
- NSF/OECD Workshop "Social and Economic Factors Shaping the Future of the Internet"
- NSF "networking" programs
  - FIND, SING, NGNI

GENI creates major opportunities for academia and industry to . . .

Understand global networks and their evolving interactions with society

Innovate at the frontiers of network science and engineering

Transform the science of network research and the larger world of communications

"Our founders"

The GENI Planning Group and Many, Many Working Group Volunteers

Larry Peterson, Princeton (Chair)
Tom Anderson, Washington
Dan Blumenthal, UCSB
Dean Casey, NGENET Research
David Clark, MIT
Deborah Estrin, UCLA
Joe Evans, Kansas
Terry Benzel, USC/ISI
Nick McKeown, Stanford
Dipankar Raychaudhuri, Rutgers
Mike Reiter, CMU
Jennifer Rexford, Princeton
Scott Shenker, Berkeley
Amin Vahdat, UCSD
John Wroclawski, USC/ISI
CK Ong, Princeton

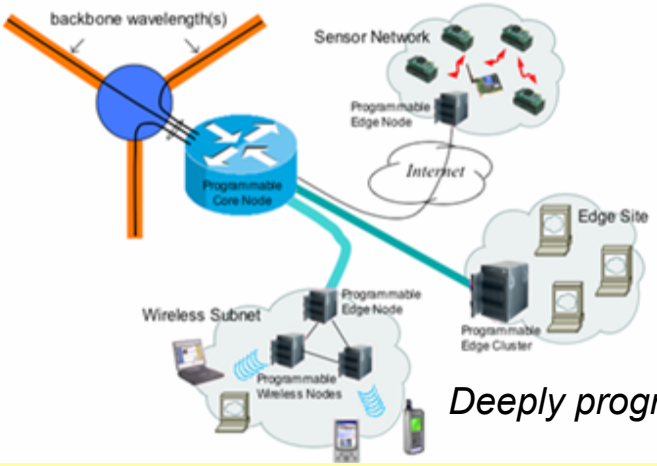
And Within NSF

Peter Freeman
Debbie Crawford
Larry Landweber
Suzi Iacono
Guru Parulkar
Darleen Fisher
Cheryl Albus
Allison Mankin
Ty Znati
Gracie Narcho
Paul Morton

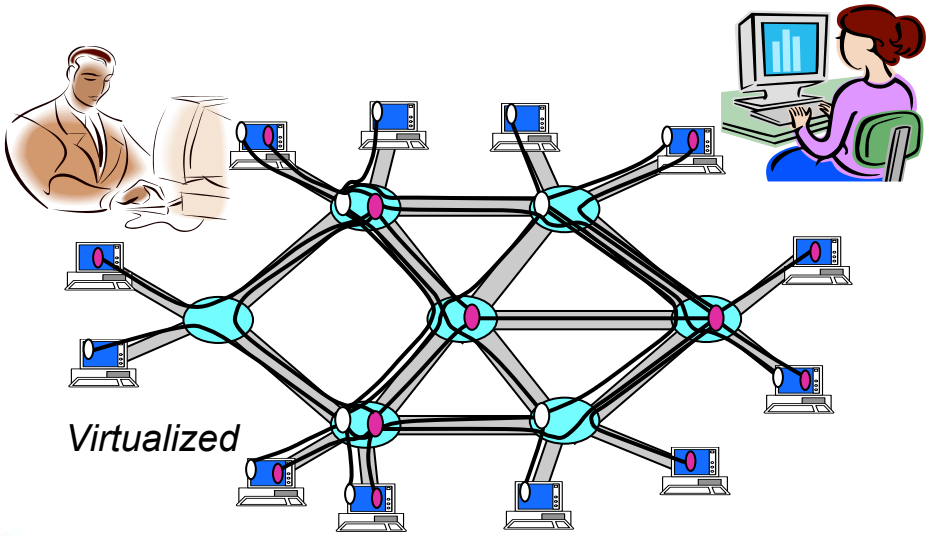
Their hard work has created GENI's Conceptual Design, the starting point for all our work going forward.

GENI Conceptual Design

Infrastructure to support at-scale experimentation

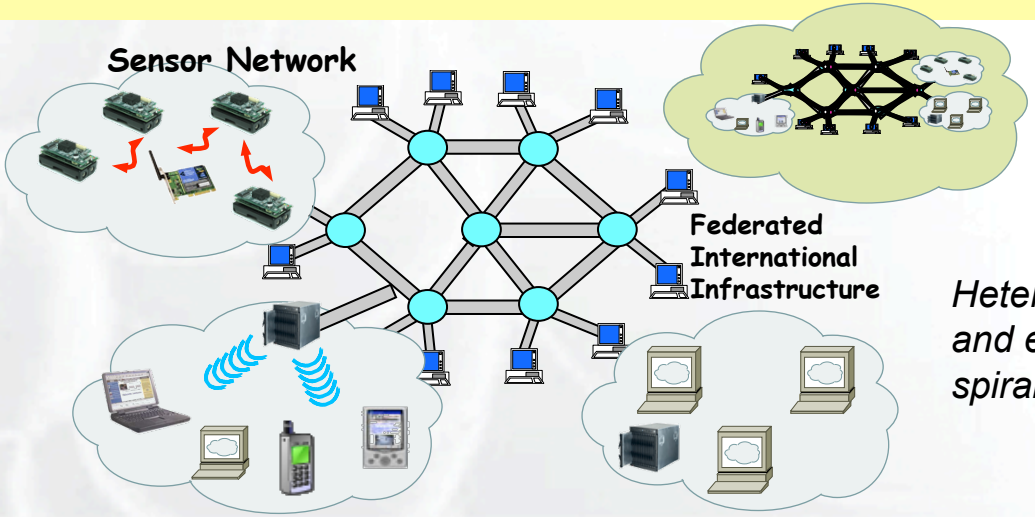


Deeply programmable



Virtualized

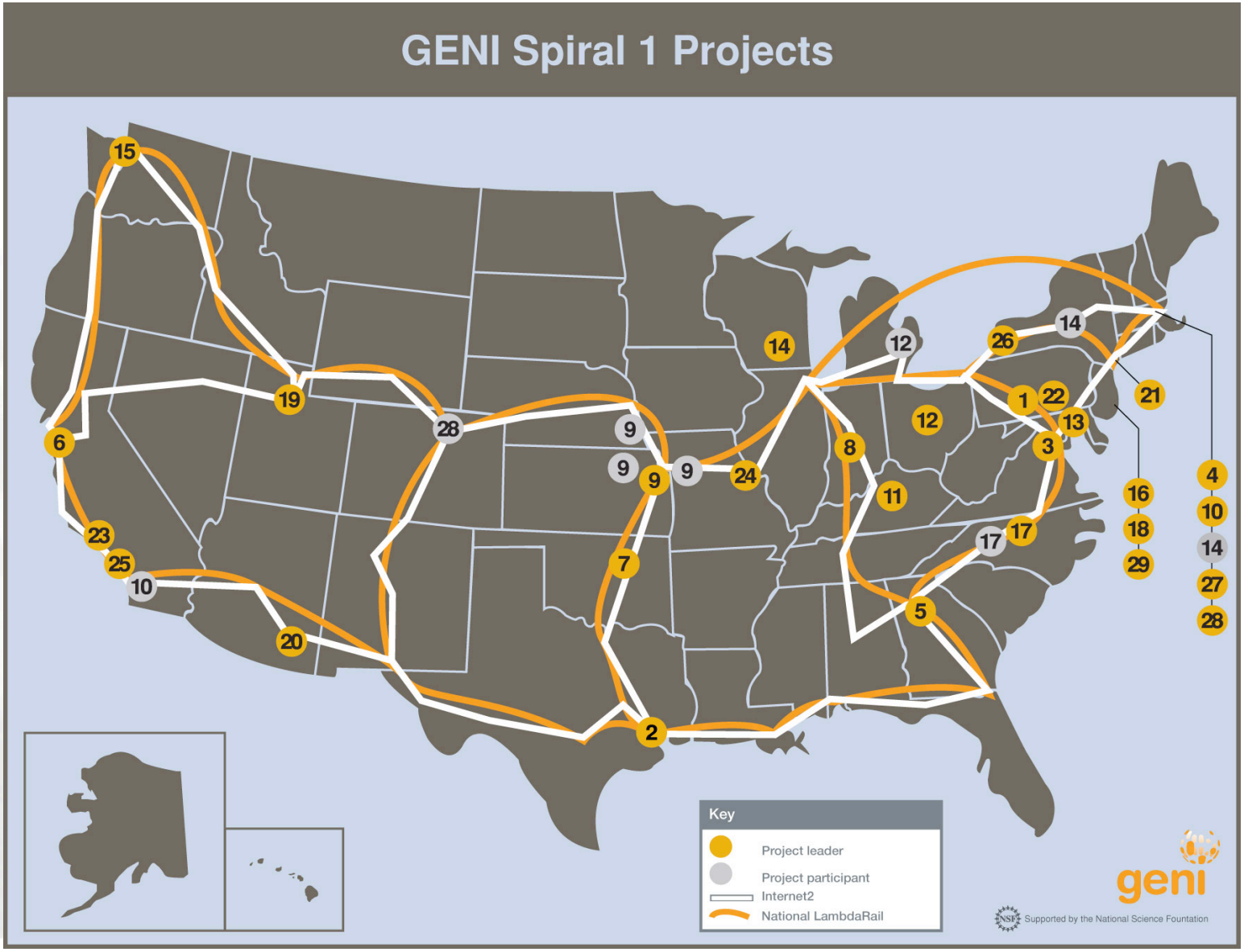
Programmable & federated, with end-to-end virtualized "slices"



Heterogeneous, and evolving over time via spiral development

Current status - GENI Spiral 1

Rapid prototyping, integration, and early experiments



Spiral 1 Academic-Industrial Teams

Project Name	Project Lead	Project Participants
1. CMUlab	Carnegie Mellon University	
2. D Meas	University of Houston	
3. Digital Object Registry	Corporation for National Research Initiatives (CNRI)	
4. DOME	University of Massachusetts Amherst	
5. DTunnels	The Georgia Institute of Technology	
6. EnterpriseGENI	Stanford University	
7. GENI4YR	Langston University	
8. GMOC	Indiana University	
9. GpENI	University of Kansas	Kansas State University, University of Nebraska-Lincoln The University of Missouri-Kansas City (UMKC)
10. GushProto	Williams College	UC San Diego
11. INSTOOLS	University of Kentucky	
12. KANSEI	Ohio State University	Wayne State University
13. MAX	University of Maryland	
14. MeasurementSys	University of Wisconsin-Madison	Boston University Colgate University
15. MillionNodeGENI	University of Washington (Seattle)	
16. ORBIT	Rutgers University	
17. ORCA/BEN	The Renaissance Computing Institute (RENCI)	Duke University
18. PlanetLab	Princeton University	
19. ProtoGENI	University of Utah	
20. PROVSERV	University of Arizona	
21. ERM	Columbia	
22. REGOPT	Pittsburgh Supercomputing Center (PSC)	
23. SECARCH	SPARTA, Inc.	
24. SPP	Washington University	
25. TIED	USC Information Sciences Institute	University of California, Berkeley
26. UB_OANets	SUNY Buffalo	
27. UMLPEN	University of Massachusetts Lowell	
28. ViSE	University of Massachusetts Amherst	
29. WiMAX	Rutgers University	

Outline

- What is GENI?
- How we'll build it, how we'll use it (Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

How We'll Use GENI

Note that this is the "classics illustrated" version – a comic book!

Please read the Network Science and Engineering Research Agenda to learn all about the community's vision for the research it will enable. Your suggestions are very much appreciated!

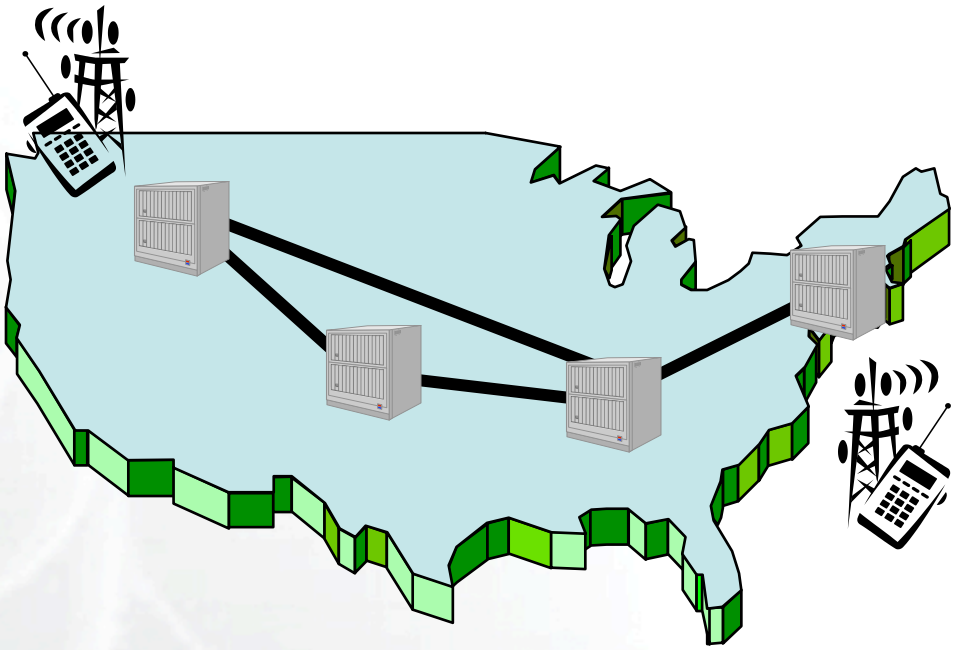
A bright idea

I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

That will never work! It won't scale! What about security? It's impossible to implement or operate! Show me!

Trying it out

My new architecture worked great in the lab, so now I'm going to try a larger experiment for a few months.



He uses a modest slice of GENI, sharing its infrastructure with many other concurrent experiments.

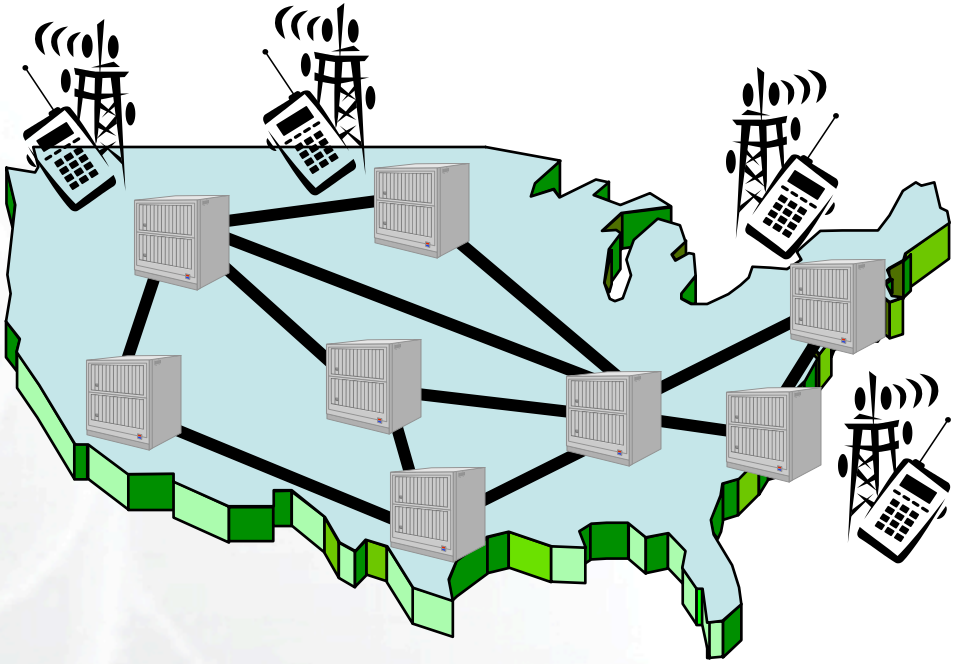
And so he poured his experimental software into clusters of CPUs and disks, bulk data transfer devices ('routers'), and wireless access devices throughout the GENI suite, and started taking measurements . . .

It turns into a really good idea

Boy did I learn a lot! I've published papers, the architecture has evolved in major ways, and I'm even attracting real users!

Location-based social networks are really cool!

His experiment grew larger and continued to evolve as more and more real users opted in . . .



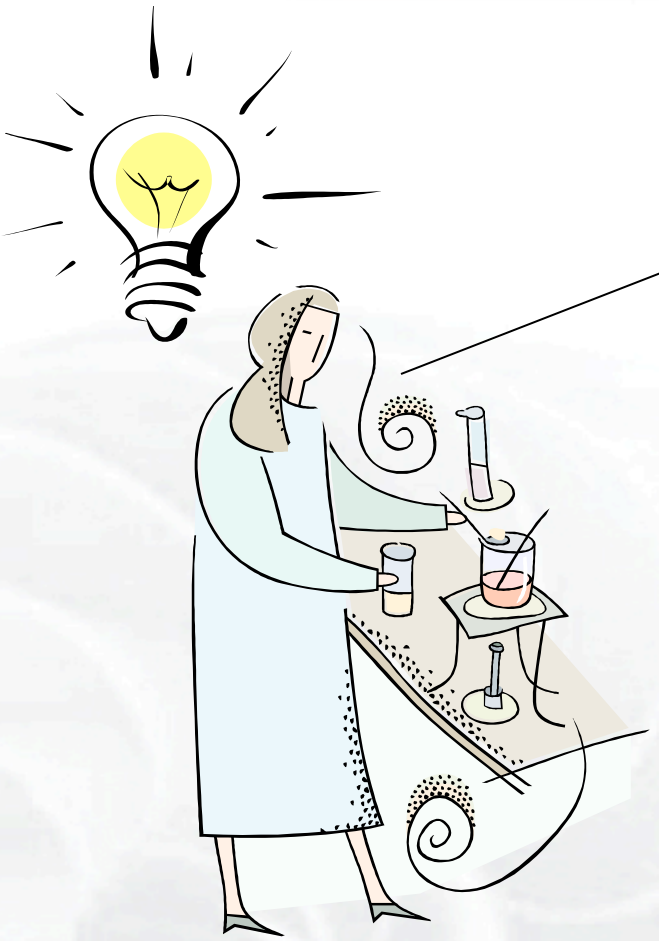
His slice of GENI keeps growing, but GENI is still running many other concurrent experiments.

Experiment turns into reality

My experiment was a real success, and my architecture turned out to be mostly compatible with today's Internet after all – so I'm taking it off GENI and spinning it out as a real company.

I always said it was a good idea, but way too conservative.

Meanwhile . . .



I have a great idea! If the Internet were augmented with a scalable control plane and realtime measurement tools, it could be 100x as reliable as it is today . . . !

And I have a great concept for incorporating live sensor feeds into our daily lives !

If **you** have a great idea, check out the **NSF CISE Network Science and Engineering** program.

Moral of this story

- GENI is meant to enable . . .
  - Trials of new architectures, which may or may not be compatible with today's Internet
  - Long-running, realistic experiments with enough instrumentation to provide real insights and data
  - 'Opt in' for real users into long-running experiments
  - Large-scale growth for successful experiments, so good ideas can be shaken down at scale
- A reminder . . .
  - GENI itself is not an experiment !
  - GENI is a suite of infrastructure on which experiments run

GENI creates a huge opportunity for ambitious research!

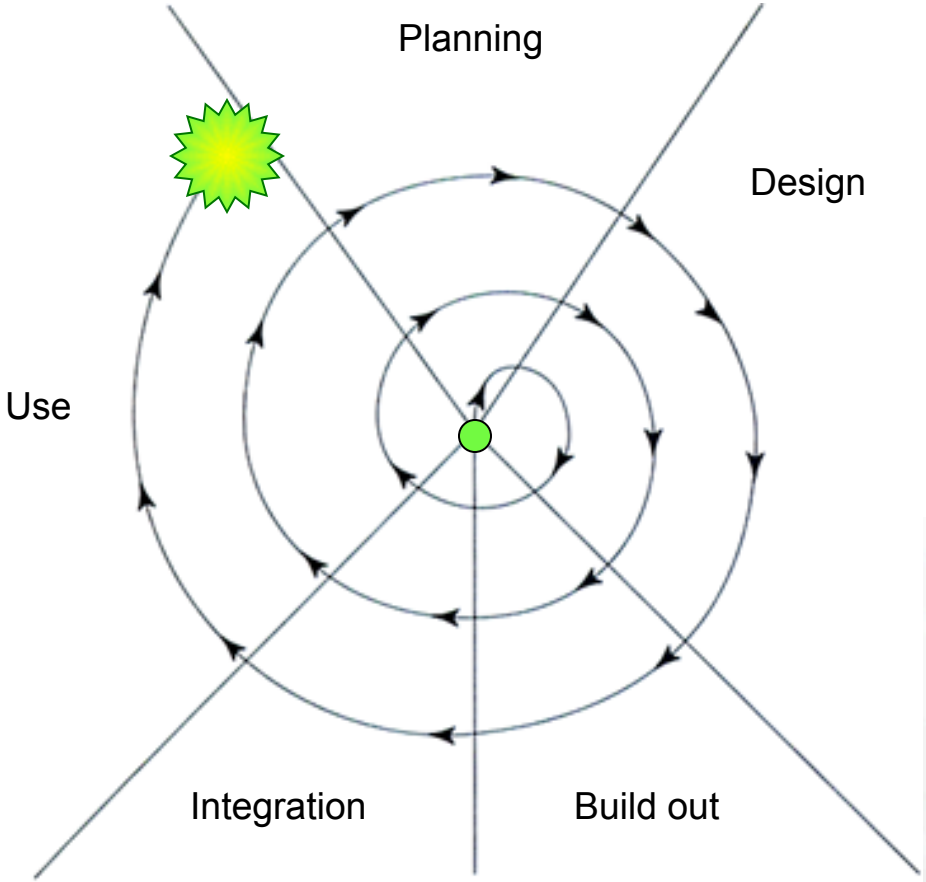
How We'll Build GENI

Note that this is the "classics illustrated" version – a comic book!

Please read the GENI System Overview and GENI Spiral 1 Overview for detailed planning information.

Spiral Development

GENI grows through a well-structured, adaptive process

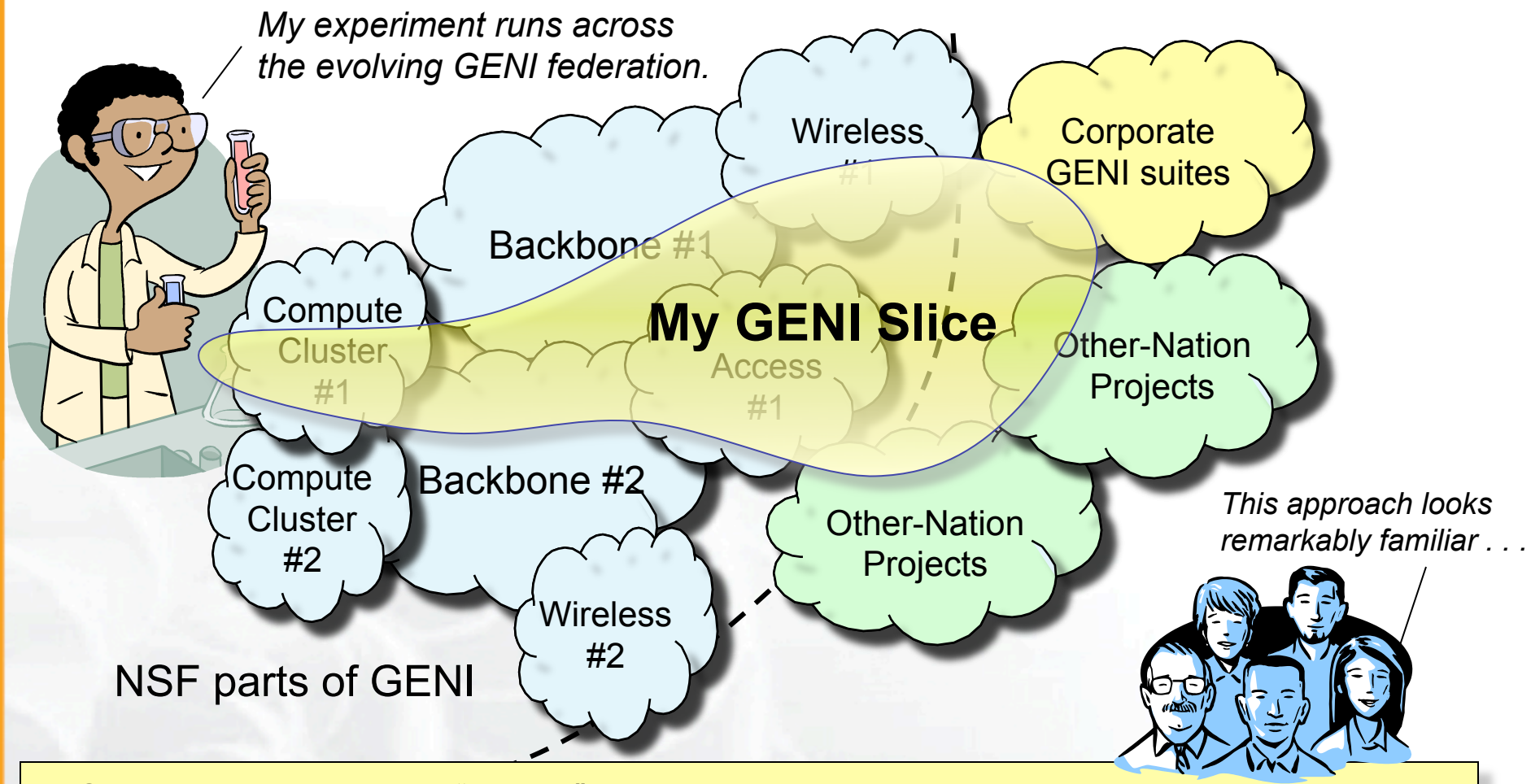


GENI Prototyping Plan

- An achievable **Spiral 1**
  Rev 1 control frameworks, federation of multiple substrates (clusters, wireless, regional / national optical net with early GENI 'routers', some existing testbeds), Rev 1 user interface and instrumentation.
- Envisioned **ultimate goal**
  Example: Planning Group's desired GENI suite, probably trimmed some ways and expanded others. Incorporates large-scale distributed computing resources, high-speed backbone nodes, nationwide optical networks, wireless & sensor nets, etc.
- Spiral Development Process
  Re-evaluate goals and technologies yearly by a systematic process, decide what to prototype and build next.

Federation

GENI grows by "gluing together" heterogeneous infrastructure



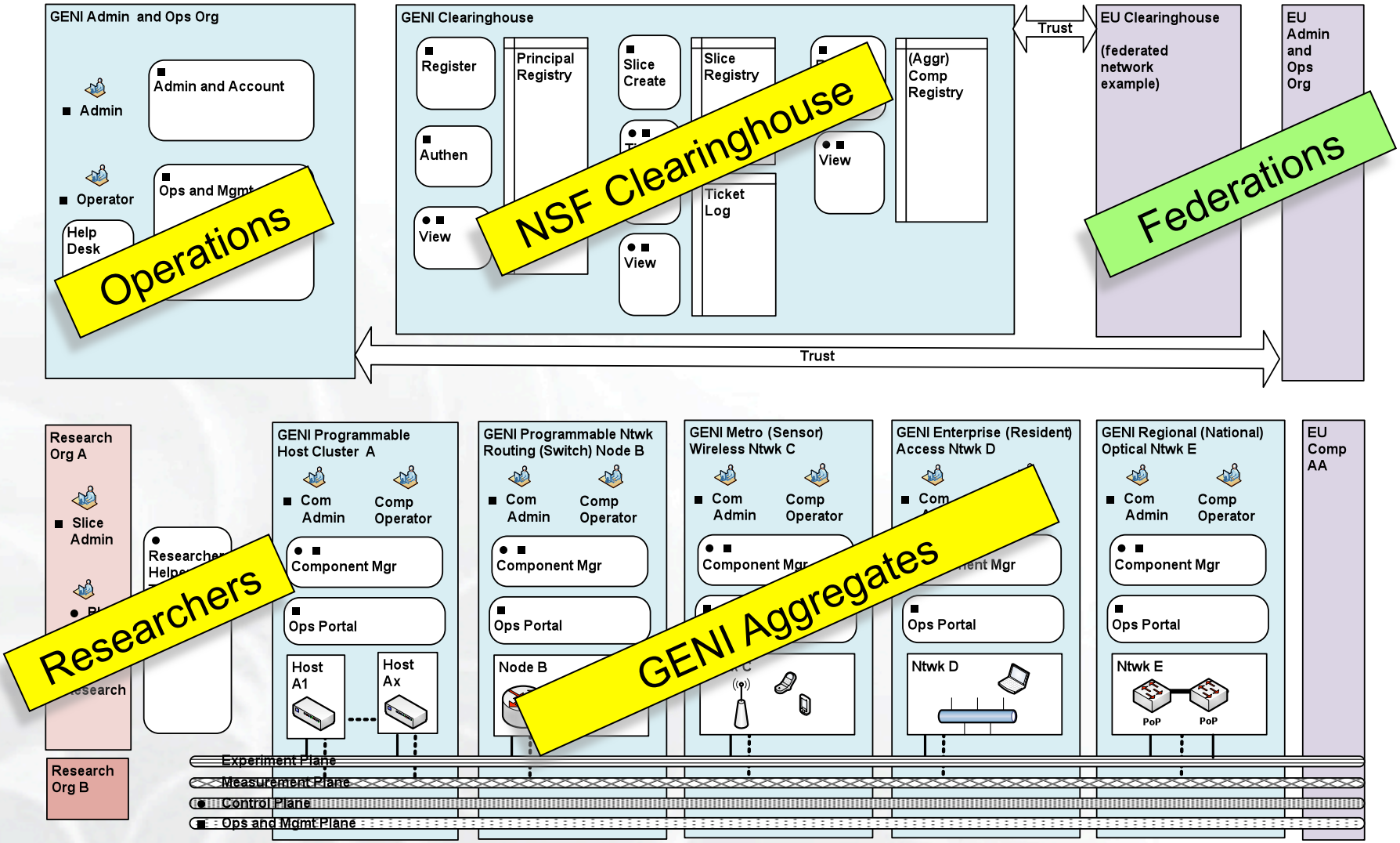
Goals: avoid technology "lock in," add new technologies as they mature, and potentially grow quickly by incorporating existing infrastructure into the overall "GENI ecosystem"

Outline

- What is GENI?
- How we'll build it, how we'll use it (Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

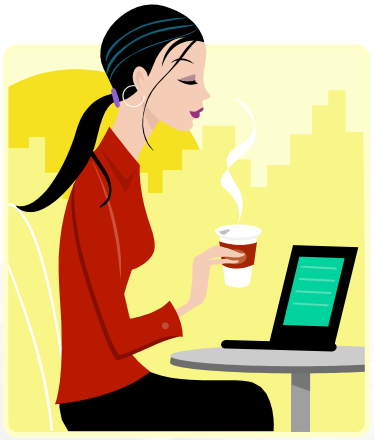
GENI System Decomposition (simplified)

Engineering analysis drives Spiral 1 integration



Resource discovery

Aggregates publish resources, schedules, etc., via clearinghouses



Researcher

What resources can I use?

GENI Clearinghouse

These

Components

Components

Components

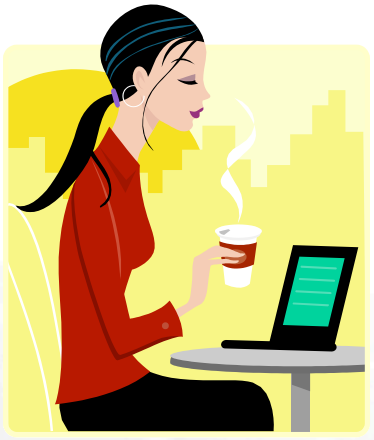
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Slice creation

Clearinghouse checks credentials & enforces policy
Aggregates allocate resources & create topologies



Create my slice

GENI Clearinghouse

Components

Components

Components

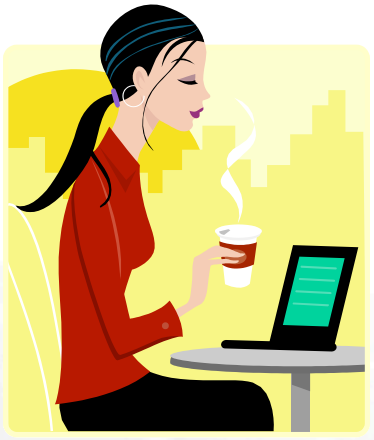
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

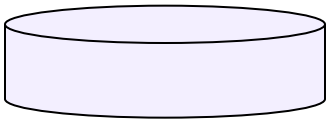
Aggregate C
Metro Wireless

Experimentation

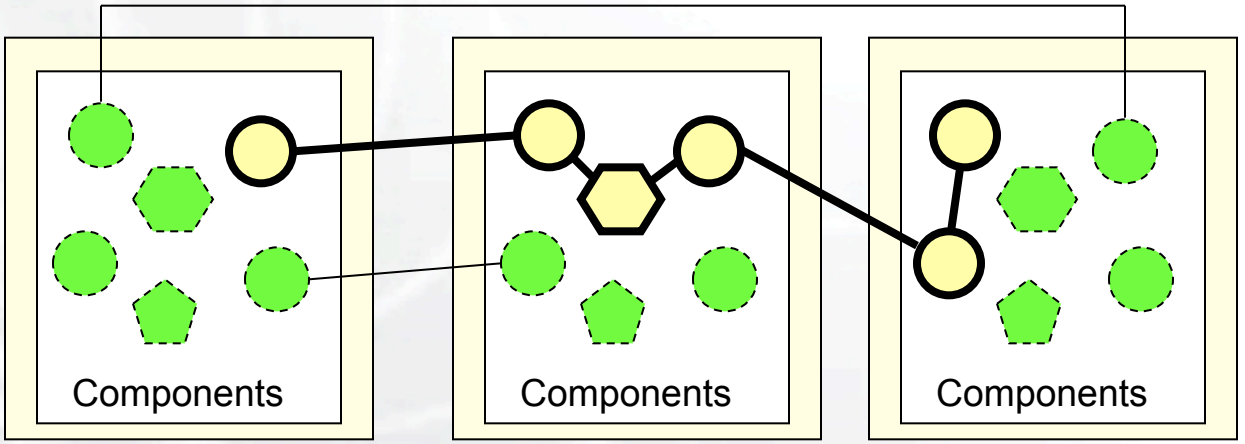
Researcher loads software, debugs, collects measurements



Experiment – Install my software, debug, collect data, retry, etc.

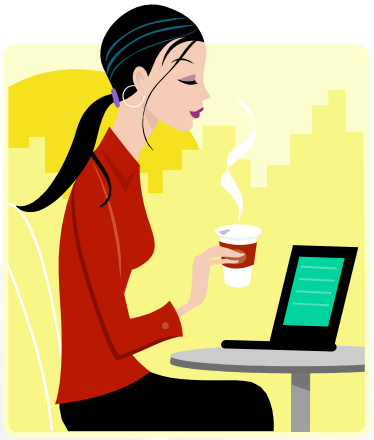


GENI Clearinghouse



Slice growth & revision

Allows successful, long-running experiments to grow larger



Make my slice bigger !

GENI Clearinghouse

Components

Components

Components

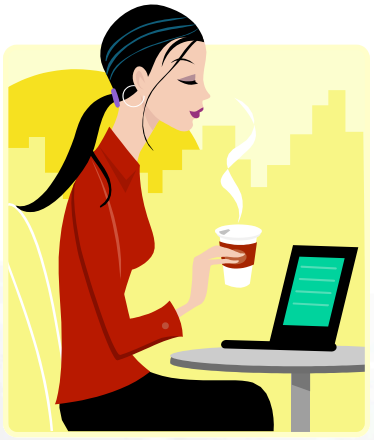
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Federation of Clearinghouses

Growth path to international, semi-private, and commercial GENIs



Make my slice even bigger !

GENI Clearinghouse

Federated Clearinghouse

Components

Components

Components

Components

Aggregate A
Computer Cluster

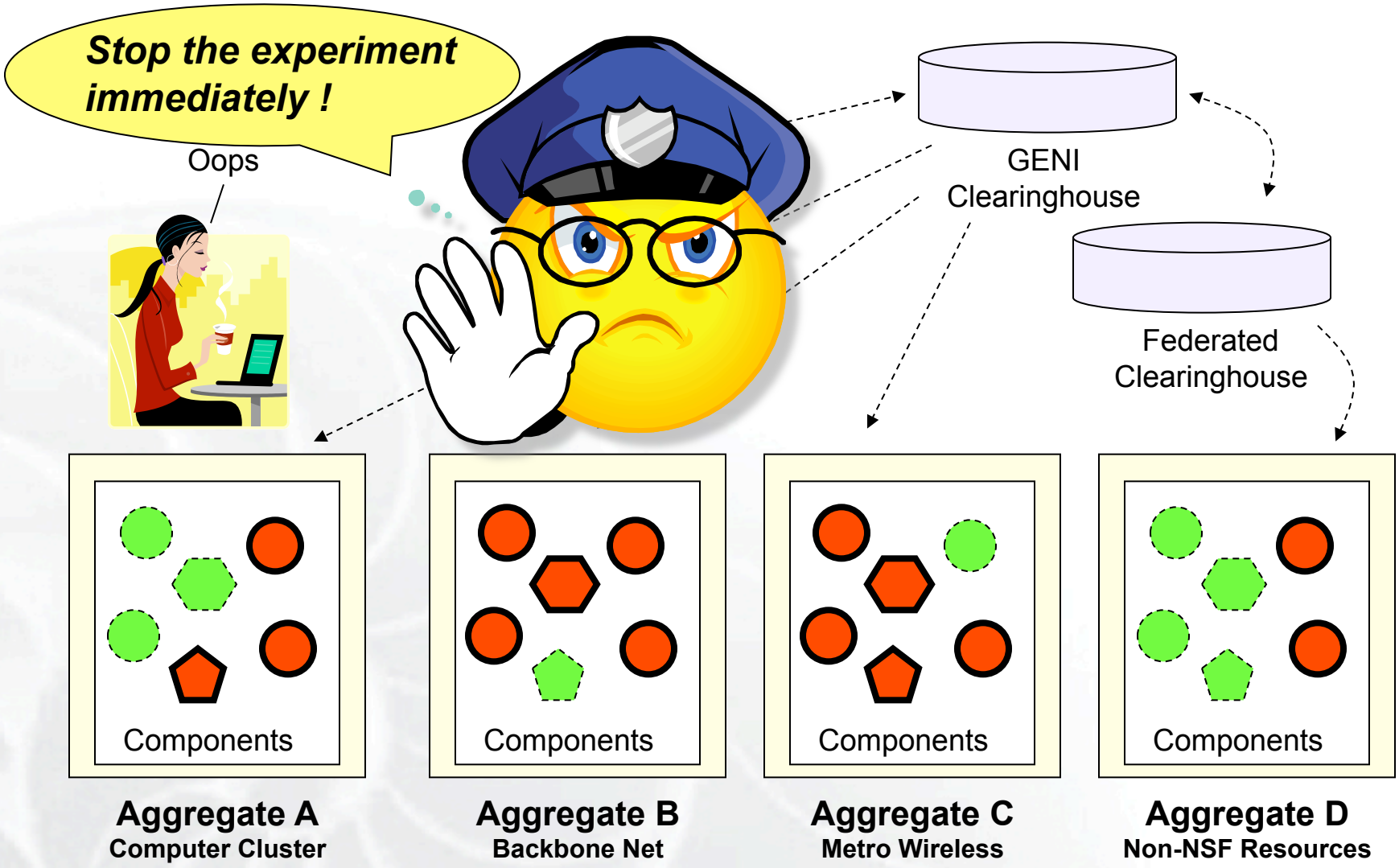
Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Aggregate D
Non-NSF Resources

Operations & Management

Always present in background for usual reasons
Will need an 'emergency shutdown' mechanism



Outline

- What is GENI?
- How we'll build it, how we'll use it (Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

GENI Spiral 1 is underway!

First results expected in 6-12 months

GENI Project Office Announces $12M for Community-Based GENI Prototype Development

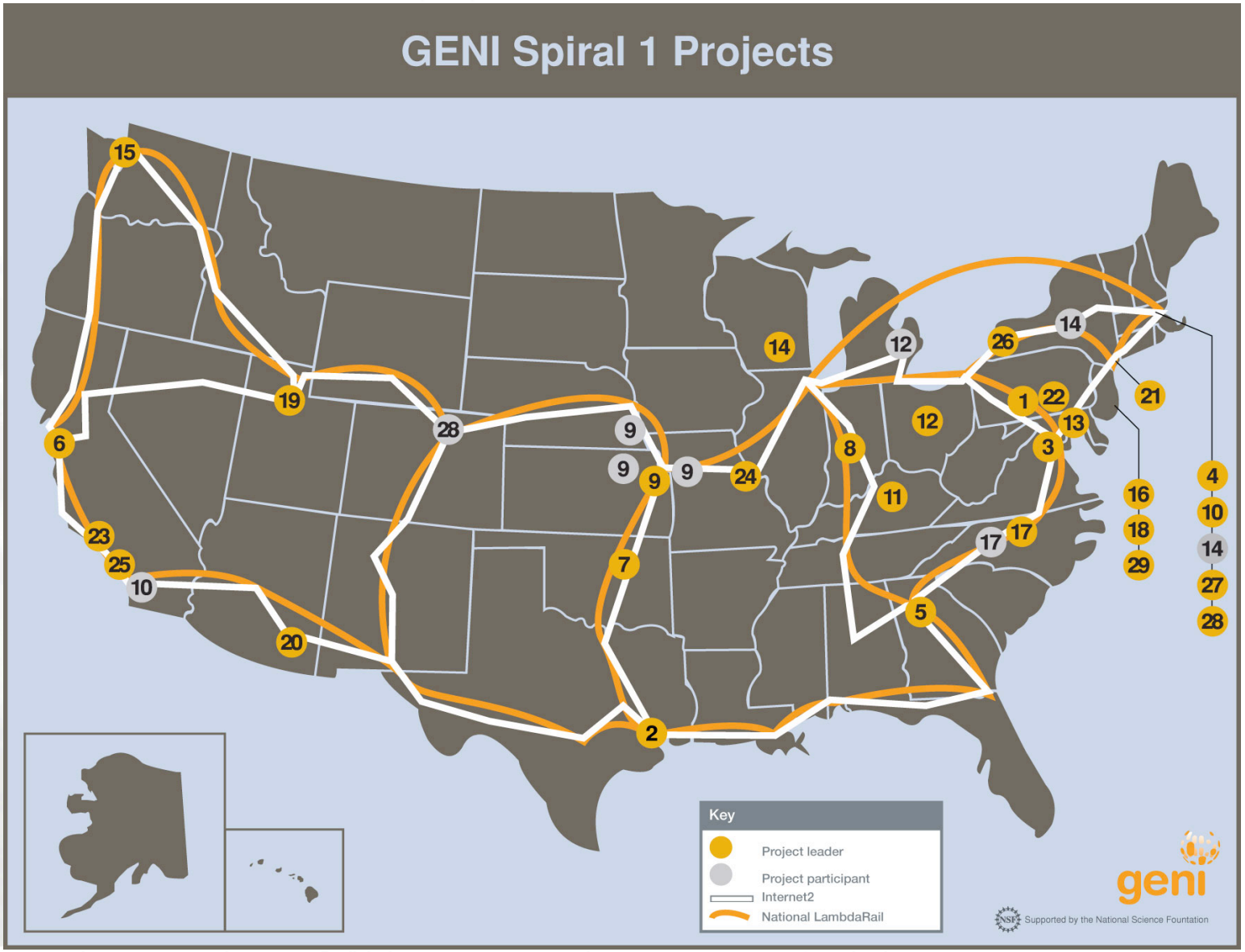
July 22, 2008

The GENI Project Office, operated by BBN Technologies, an advanced technologies solutions firm, announced today that it has been awarded a **three year grant worth approximately $4M a year** from the US National Science Foundation to perform GENI design and risk-reduction prototyping.

The funds will be used to contract with **29 university-industrial teams** selected through an open, peer-reviewed process. The first year funding will be used to **construct GENI Spiral 1, a set of early, functional prototypes** of key elements of the GENI system.

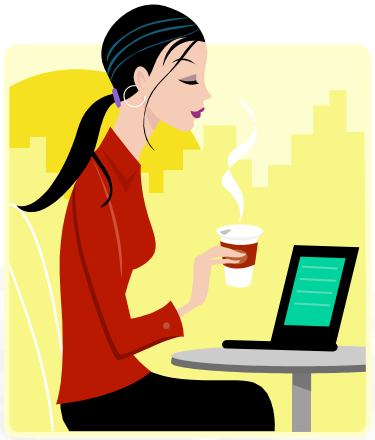
GENI Spiral 1

Rapid prototyping, integration, and early experiments



GENI's Critical Technical Risks

These risks drive the Prototyping Goals for GENI Spiral 1



Create my slice

GENI
Clearinghouse

Critical Risk #1
Clearinghouse & control framework is central but never demonstrated

Critical Risk #2
End-to-end slices across multiple technologies have never been demonstrated

Components

Components

Components

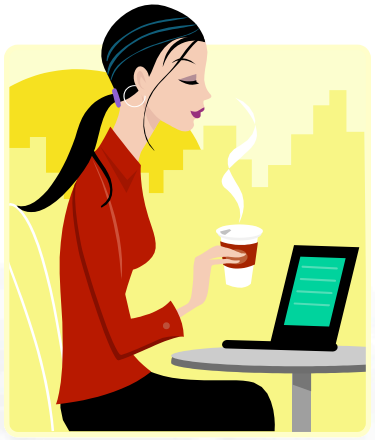
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Key Goals for GENI Spiral 1

Drive down critical technical risks in GENI's concept



Create my slice

GENI
nghouse

Goal #1
Fund multiple, competing teams to develop GENI Clearinghouse technology, encourage strong competition within the first few spirals

Goal #2
Demonstrate end-to-end slices across representative samples of the major substrates / technologies envisioned in GENI

Components

Components

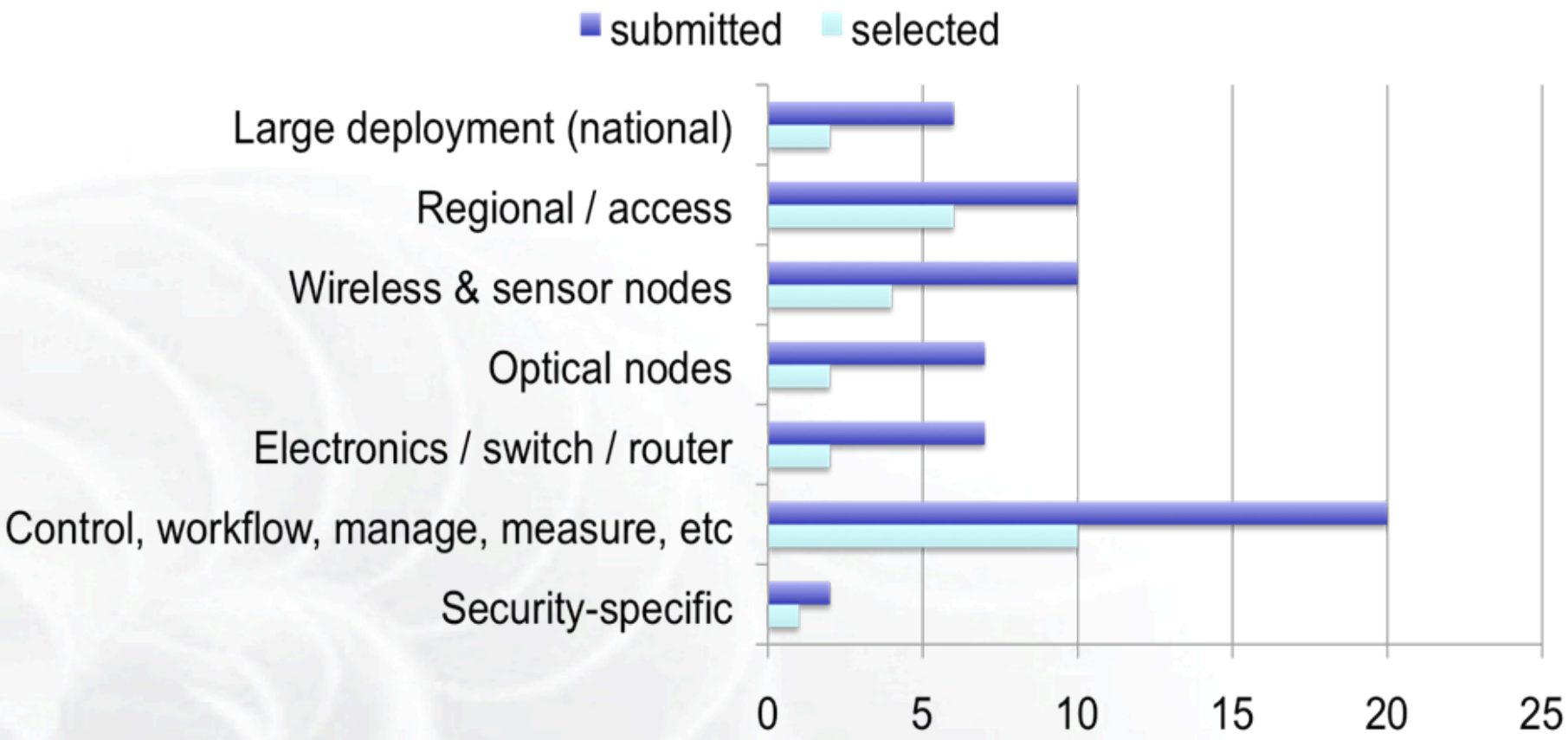
Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

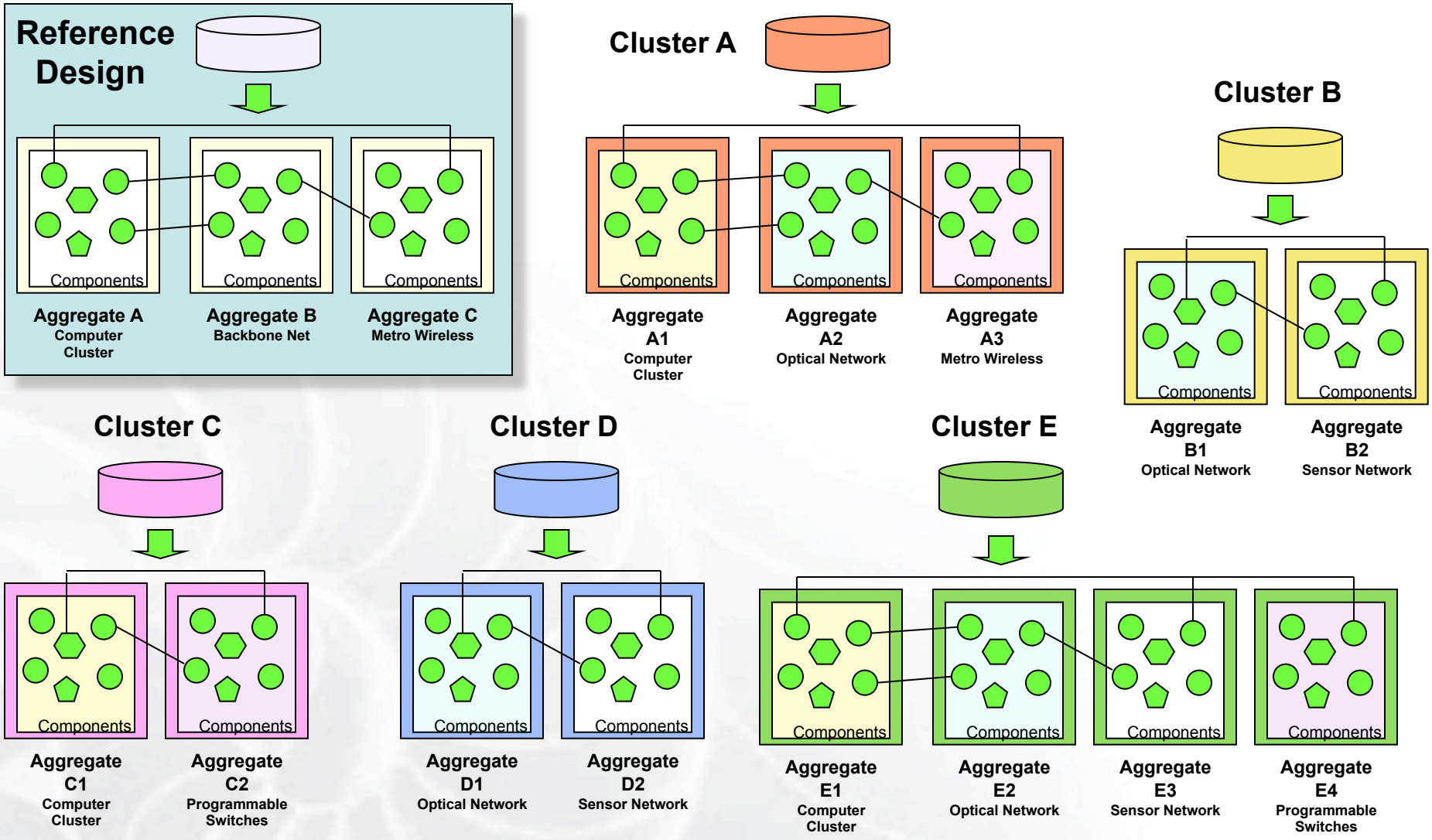
Aggregate C
Metro Wireless

1st GENI Solicitation – proposal areas

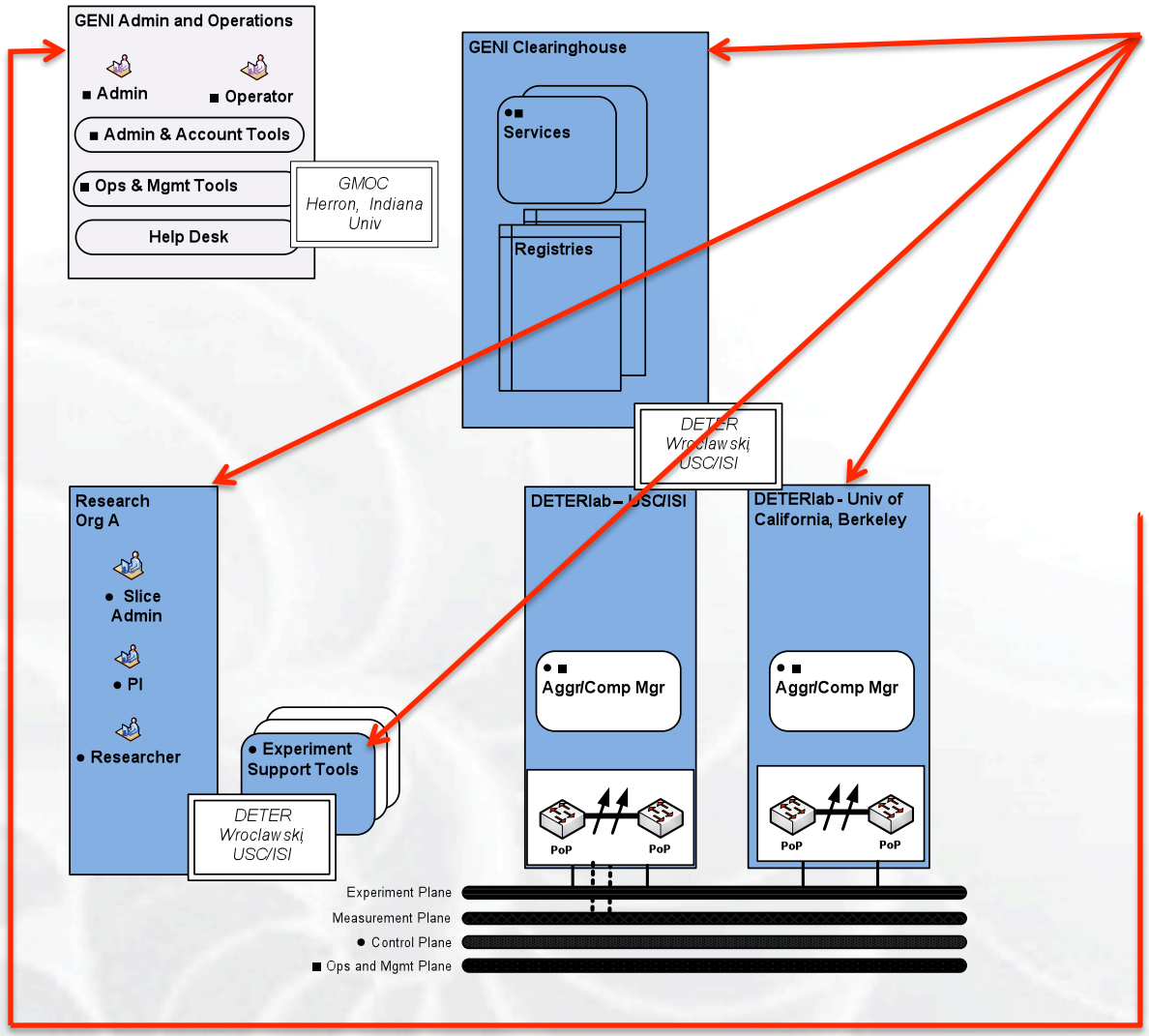


Spiral 1 integration and trial operations

Five competing control frameworks, wide variety of substrates



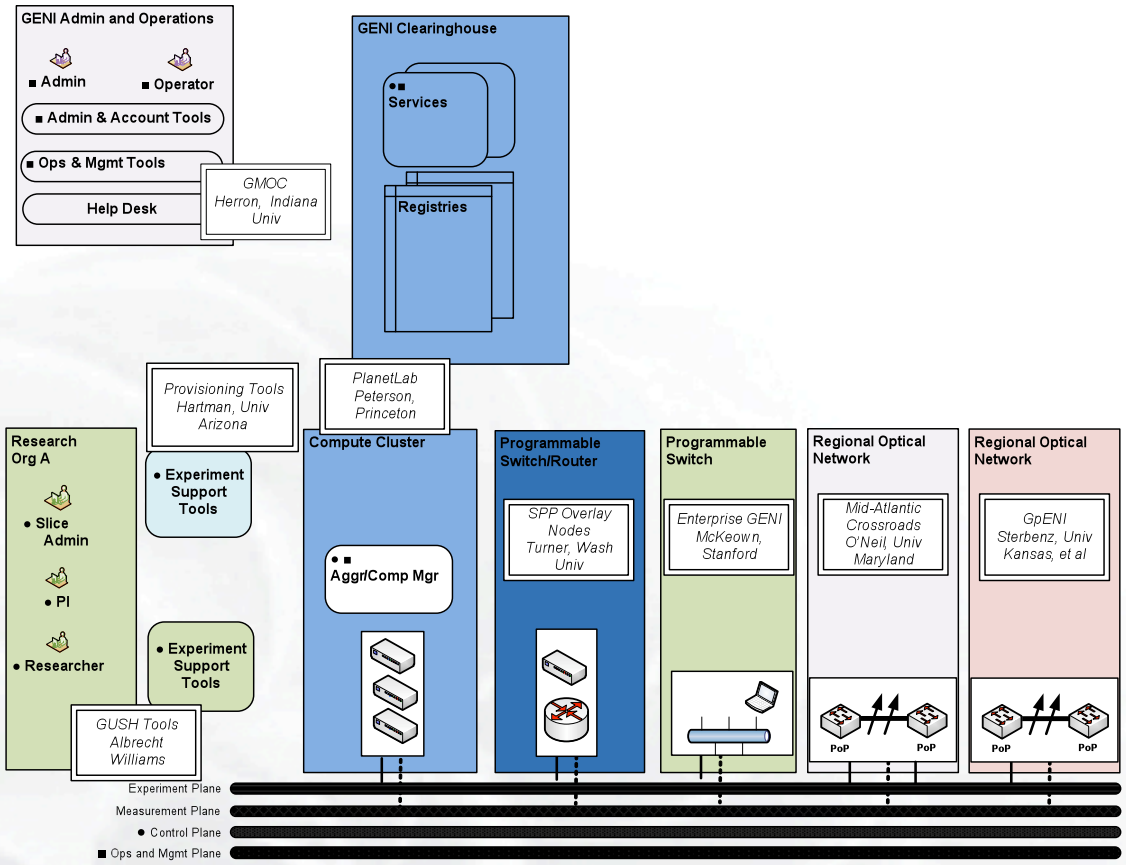
Cluster A Integration (uses TIED/DETER control framework)



- DETER Trial Integration
  - DETER security testbed
  - Emphasis on federation
  - Clearinghouse, CM
  - 100+ nodes at ISI, UC Berkley
- GMOC
  - Global Research NOC (Indiana)

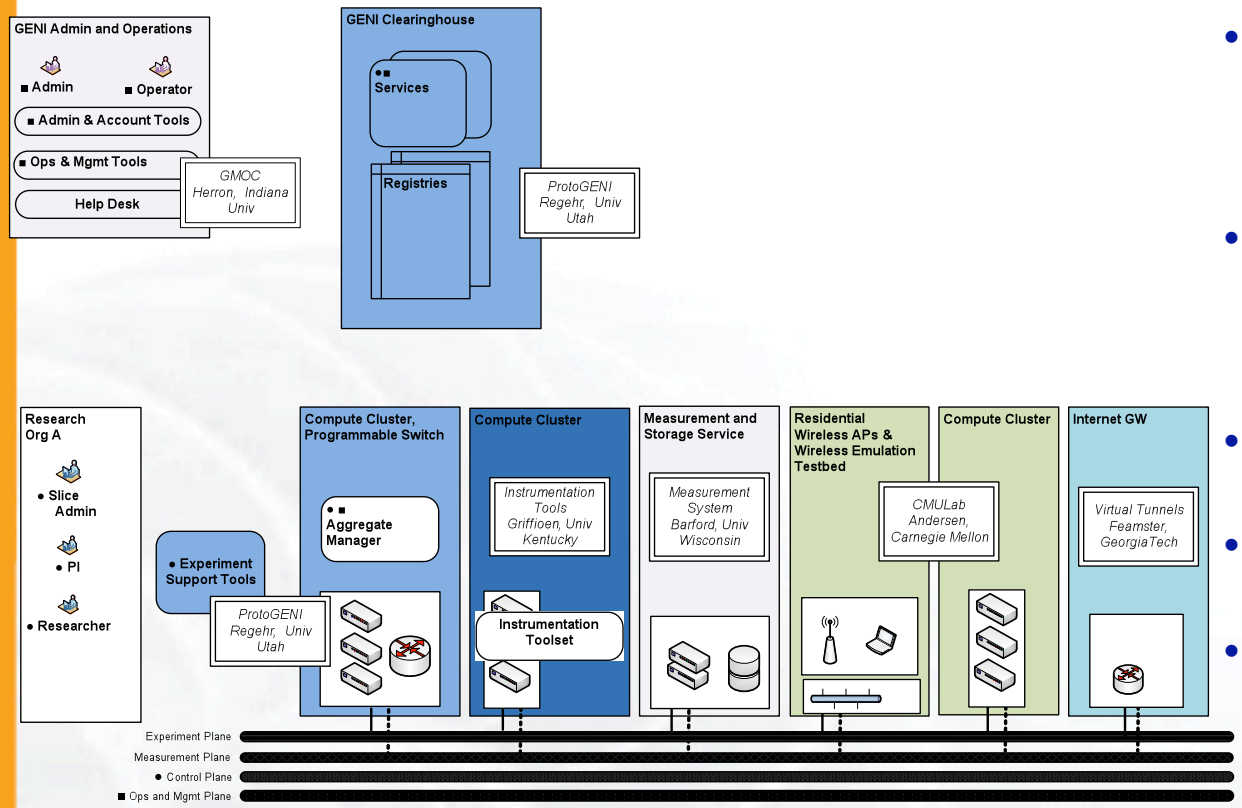
38

Cluster B Integration (uses PlanetLab control framework)



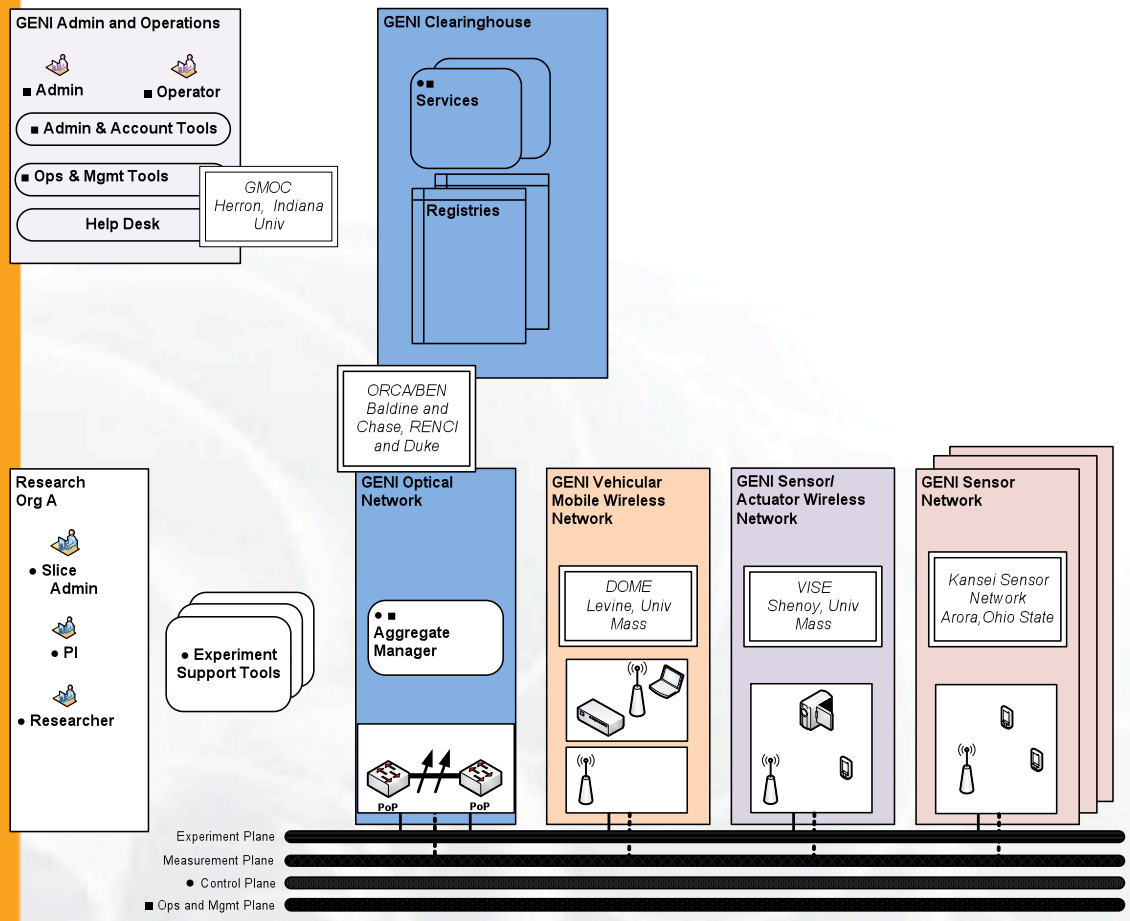
- PlanetLab
  - Clearinghouse, CM
  - 800+ nodes
  - VINI (virtual topologies)
- Enterprise GENI
  - GENI VLANs on enterprise nets
- SPP Overlay Nodes
  - Programmable routers
- GUSH Tools
  - Experiment design tools
- Provisioning Service
  - Slice & experiment management tools
- Mid-Atlantic Crossroads
  - Regional network with VLAN control plane
- GpENI
  - Regional network with sliceable optics & routers
- GMOC

Cluster C Integration (uses ProtoGENI/Emulab Control Framework)



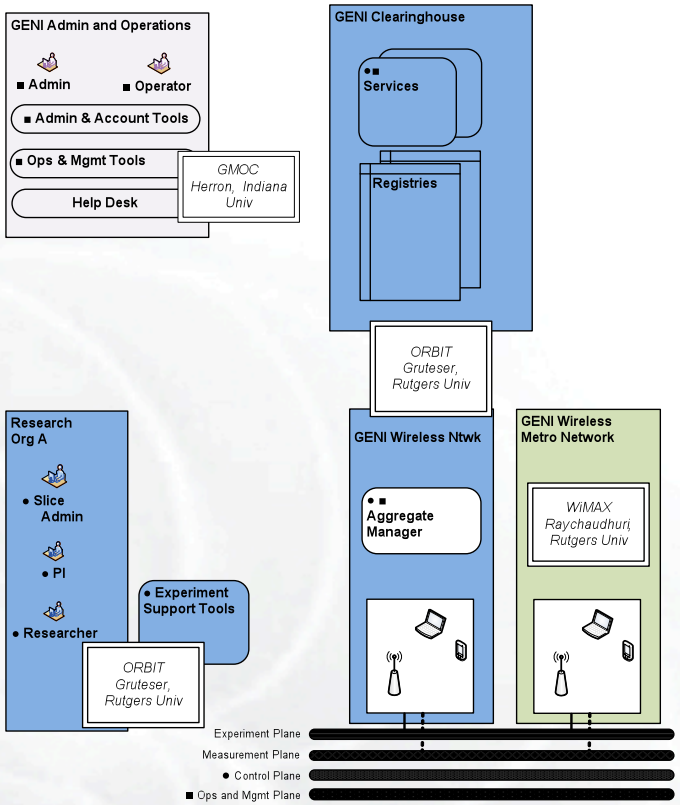
- ProtoGENI
  - Clearinghouse, CM
  - Emulab resources
  - (370+ nodes)
- CMULab
  - Home Wireless APs
  - Emulab cluster
  - Wireless emulation testbed
- Instrumentation Tools
  - UK Edulab (compute/store)
- Measurement System
  - GIMS prototype
- Virtual Tunnels
  - Dynamic tunnel tools
  - BGP distribution tools
- GMOC

Cluster D Integration (uses ORCA Control Framework)



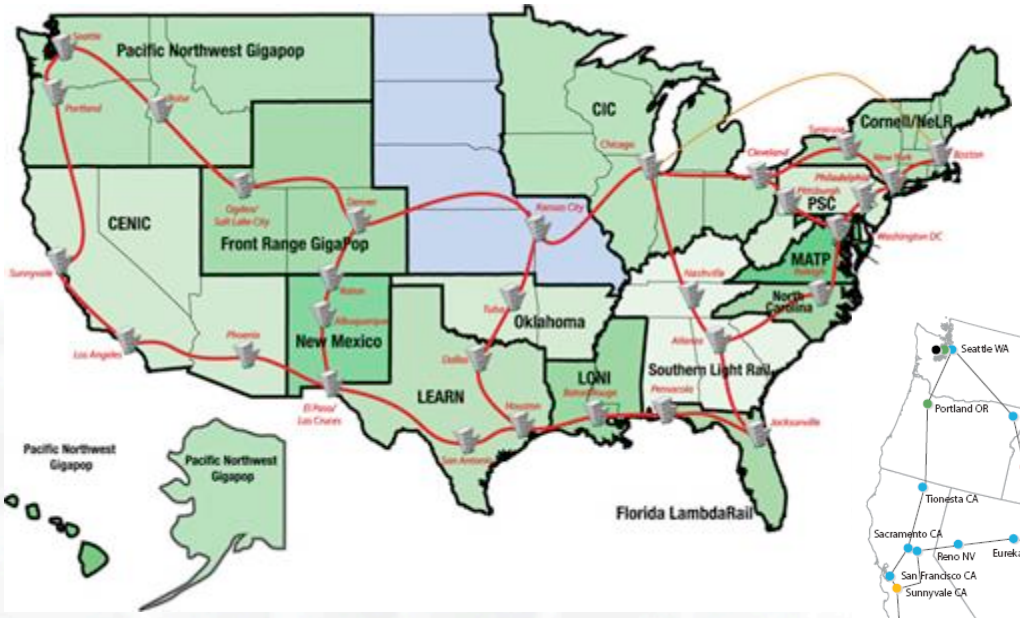
- ORCA/BEN
  - ORCA resource leasing software
  - Metro-Scale Optical Testbed (BEN)
- VISE
  - CASA (radar, video, weather sensors)
- Kansei Sensor Network
  - Wireless sensor network arrays
  - 3 federated sites each w/~100 sensor nodes
- Diverse Outdoor Mobile Environment (DOME)
  - Programmable nodes with radios on city busses
- GMOC

Cluster E Integration (uses ORBIT control framework)



- ORBIT
  - Heterogeneous testbed control, management, & measurement software
  - WINLAB wireless testbeds resources (400+ sensor nodes)
  - NICTA (Australia) wireless outdoor traffic testbed
- WiMAX
  - Open, programmable WiMAX base station
- GMOC

Internet2 and National Lambda Rail

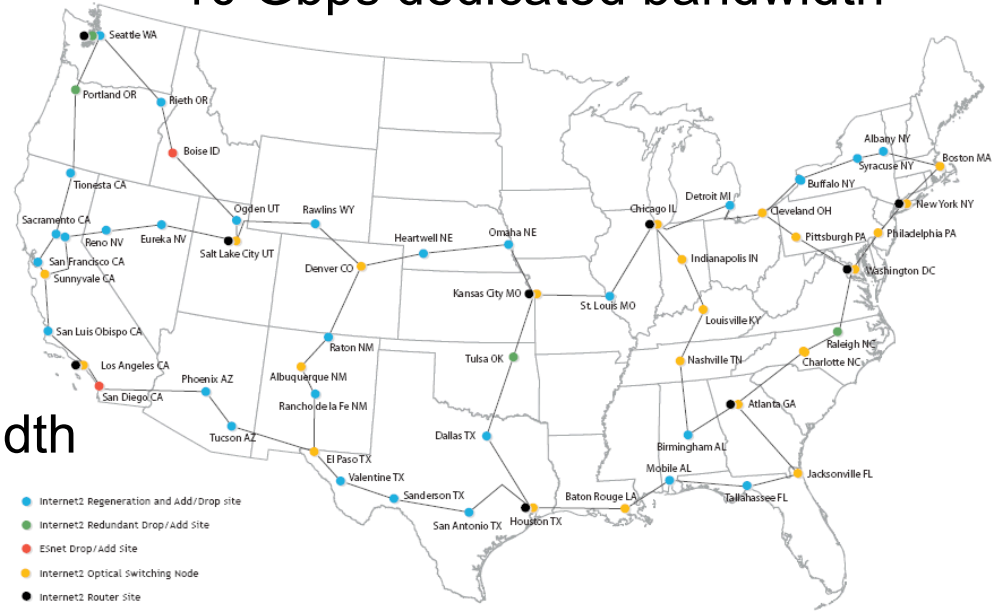


National Lambda Rail

Up to 30 Gbps nondedicated bandwidth

Internet2

10 Gbps dedicated bandwidth



40 Gbps capacity for GENI prototyping on two national footprints to provide Layer 2 Ethernet VLANs as slices (IP or non-IP)

Currently in the works

Prototyping GENI through campuses

- August Meeting at O'Hare
  - Thanks to EduCause (Mark Luker, Garret Sern)
  - Stimulated by Larry Landweber
- CIOs from 11 major research universities
  - Berkeley, Clemson, GA Tech, Indiana, MIT, Penn State, Rice, U. Alaska, UIUC, UT Austin, U. Wisconsin
- Discussions of representative GENI prototypes
  - Nick McKeown, Stanford (OpenFlow)
  - Arvind Krishnamurthy, UW (Million Node GENI)
  - GPO Staff
- Near-term GENI / CIO activities
  - How to "GENI-enable" campus IT infrastructure
  - Coordinated policy for handling side-effects of network research (Larry Peterson, Helen Nissenbaum)

GENI Spiral 1

- Provides the very first, national-scale prototype of an interoperable infrastructure suite for Network Science and Engineering experiments
- Creates an end-to-end GENI prototype in 6-12 months with broad academic and industrial participation, while encouraging strong competition in the design and implementation of GENI's control framework and clearinghouse
- Includes multiple national backbones and regional optical networks, campuses, compute and storage clusters, metropolitan wireless and sensor networks, instrumentation and measurement, and user opt-in
- Because the GENI control framework software presents very high technical and programmatic risk, the GPO has funded multiple, competing teams to integrate and demonstrate competing versions of the control software in Spiral 1

Nothing like GENI has ever existed; the integrated, end-to-end, virtualized, and sliceable infrastructure suite created in Spiral 1 will be entirely novel.

Outline

- What is GENI?
- How we'll build it, how we'll use it (Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

GENI in Context

Supports the Evolving NetSE Research Agenda

NSF CISE

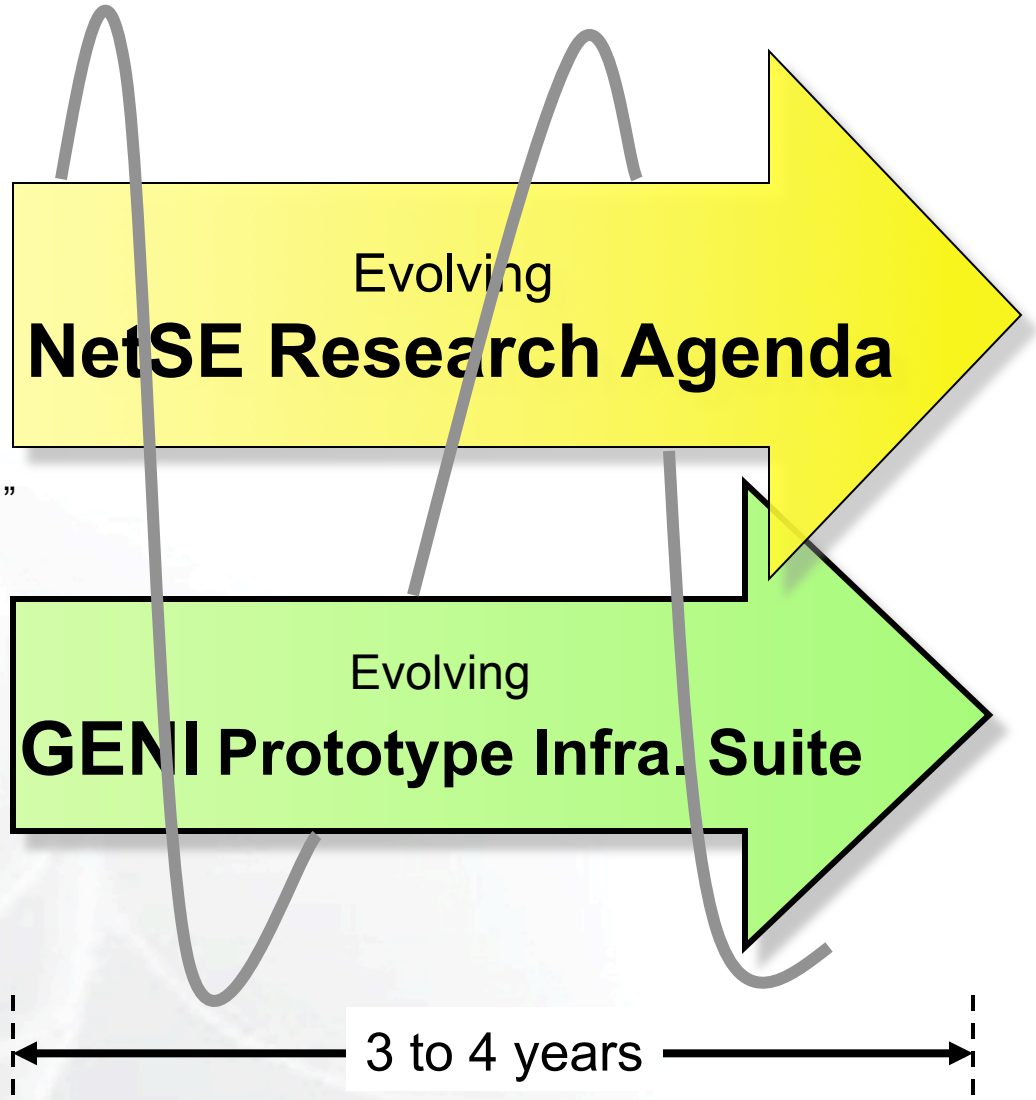
Network Science & Engineering (NetSE) Council

"Voice of the Community"

- Definitive source of "what we need in GENI"
- Authors of GENI Research Agenda
- Technical advisory to GPO

GENI Project Office (GPO)

- Project management
- System engineering
- Prototype selection, funding, guidance
- Integration and early trials
- Home for Working Groups



NetSE Council


Ellen Zegura (Chair)


Tom Anderson (UW)


Joe Berthold (Ciena)


Charlie Catlett (Argonne)


Mike Dahlin (UT Austin)


Chip Elliott (GPO)


Joan Feigenbarum (Yale)


Stephanie Forrest (UNM)


Jim Hendler (RPI)


Michael Kearns (U.Penn)


Ed Lazowska (UW)


Peter Lee (CMU)


Larry Peterson (Princeton)


Jennifer Rexford (Princeton)


Alfred Spector (Google)

And not shown . . .

Roscoe Giles
Helen Nissenbaum

GENI is being Designed & Built by the Community
Via an Open, Transparent, & Fair GPO Process

- All design, prototyping, & construction will be performed by the research community (academia & industry)
- Openness is emphasized
  - Design process is open, transparent, and broadly inclusive
  - Open-source solutions are strongly preferred
  - Intellectual property is OK, under no-fee license for GENI use
- GPO will be fair and even-handed
  - BBN brings no technology to the table
  - BBN does not intend to write any GENI software, nor does it envision bidding on any prototyping or construction activities (but “never say never”)
  - If BBN does create any GENI technology, it will be made public at no cost

Working Groups drive GENI's Technical Design

Meet every 4 Months to Review Progress Together

- **Working Groups**, open to all
  - The locus for all GENI technical design
  - Patterned on the early IETF
  - Discuss by email, create documents, meet 3x per year in person
  - Each led by Chair(s), plus a professional System Engineer
- **GENI Engineering Conferences**, open to all who fit in the room
  - Held at regular 4-month periods
  - Held on / near university campuses (volunteers?)
  - All GPO-funded teams required to participate
  - Systematic, open review of each Working Group status (all documents and prototypes / trials / etc.)
  - Also time for Working Groups to meet face-to-face
  - Results in prioritized list for next round of prototype funding areas (priorities decided by NetSE and GPO)

GENI Working Groups (WGs)

Open to all, participate via **geni.net** email and wiki

- **Substrates**
  All hardware, real-estate, facilities, etc., required for the GENI infrastructure suite (including optical networks, wireless, computers, etc.)
- **Control Framework with Federation**
  Written definitions of the core GENI mechanisms for providing experimental control of a node or collection of nodes. The very earliest version must incorporate federation.
- **Experiment Workflow**
  Tools and mechanisms by which a researcher designs and performs experiments using GENI. Includes all user interfaces for researchers, as well as data collection, archiving, etc.
- **User Opt-In**
  How do "real users" (not researchers) participate in GENI experiments. Includes both mechanisms and considerations such as privacy, etc.
- **Operations, Management, Integration, and Security**
  How do operators provision, operate, manage, and trouble-shoot GENI? Includes all mechanisms for integrating and securely operating the GENI infrastructure suite.

GENI Engineering Conferences
Meet every 4 months to review progress together

- **4th meeting March 31-April 2, 2009, Miami, open to all**
  - Team meetings, integrated demos, Working Group meetings
  - Also discuss GPO solicitation, how to submit a proposal, evaluation process & criteria, how much money, etc.
  - **Travel grants** to US academics for participant diversity
- Subsequent Meetings, open to all who fit in the room
  - Held at regular 4-month periods
  - Held on / near university campuses (volunteers?)
  - All GPO-funded teams required to participate
  - Systematic, open review of each Working Group status (all documents and prototypes / trials / etc.)
  - Also time for Working Groups to meet face-to-face
  - Discussion will provide input to subsequent spiral goals

GPO Solicitations
Academic-industrial teams favored but not required

- **Second solicitation closed on Feb. 20, 2009**

- What kinds of proposals do we solicit?
  - Analyses & idea papers
  - Prototypes of high-risk GENI technology
  - Integrations and trials of prototypes
- How are proposals judged?
  - Merit review
  - Joint academic / industrial teams are favored but not required
  - Open source will be favored but not required
    (IP licenses on www.geni.net)

GENI Solicitation 2 – Proposals due Feb. 20

- Overview
  - Solicitation issued December 2008
  - Proposals due February 20, 2009
  - Total funds ~ $3.5 M / yr for 3 years, as always subject to availability of funds
  - Existing / new GENI participants both welcome
- Strong preference given to . . .
  - Joint Academic / Industrial teams
  - Active participation of campus / regional infrastructure providers (e.g., letter from campus CIO)
- Main solicitation interests
  - Security design and analysis for GENI
  - Experimental workflow prototypes
  - Instrumentation and measurement prototypes
  - Early tries at international federation
  - Other good ideas

www.geni.net
Solicitation and background information

GENI is a Huge Opportunity

- **GENI is an unbelievably exciting project for the community**
  - Our research community has changed the world profoundly. GENI opens up a space to do it again.
- **We believe the whole community will build GENI together**
  - Our vision is for a very lean, fast-moving GPO, with substantially all design and prototyping performed by academic and industry research teams.
- **GENI Spiral 1 is now underway !**
  - within a GENI project framework that is open, transparent, and broadly inclusive.

www.geni.net

Clearing house for all GENI news and documents

Introduction to the Substrate Working Group

GENI Engineering Conference 4
Miami, FL

John Jacob

March 31, 2009

www.geni.net

Sponsored by the National Science Foundation

Who Am I?

- John Jacob
  - Background: Optical Communications and Networking
    - Research, Hardware Development, Systems Deployment
  - GPO Substrate Systems Engineer
    - Technical POC on 8 Spiral-1 projects

Substrate Working Group Chairs

- Patrick Crowley – Washington University, St. Louis
- Joseph Evans – University of Kansas
- Peter O'Neil – Mid Atlantic Crossroads

My role in this working group

- Frame issues from top-down through document development
  - Collect & frame issues
  - Collect input from group & revise
- Synthesize input from bottom-up
  - Test for & document consensus (or lack of it)
  - Take & distribute notes
  - Maintain wiki

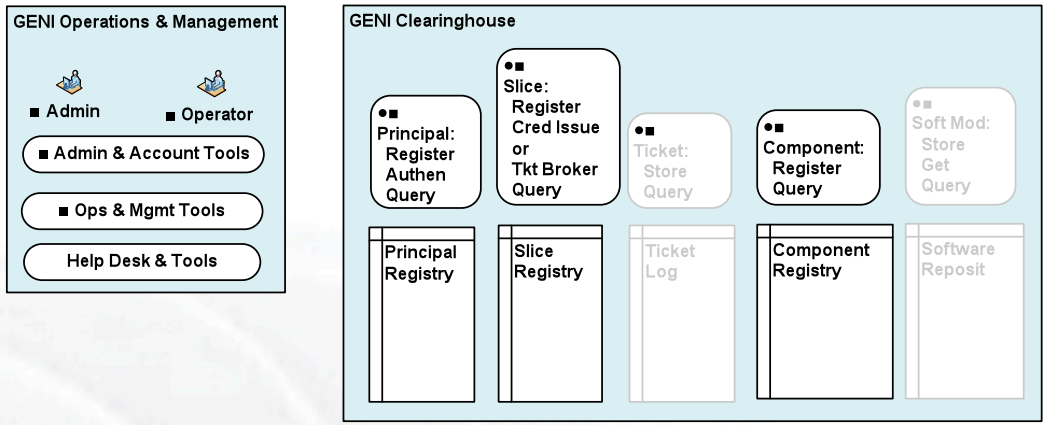
Working Groups and GPO System Engineering

- SE's draft documents
- Internal GPO review
- Post publically
  - on wiki initially, repository up RSN
- Discuss doc on working group list and GEC's
  - Possible one-on-one followups
- Revision is posted
  - Repeat process

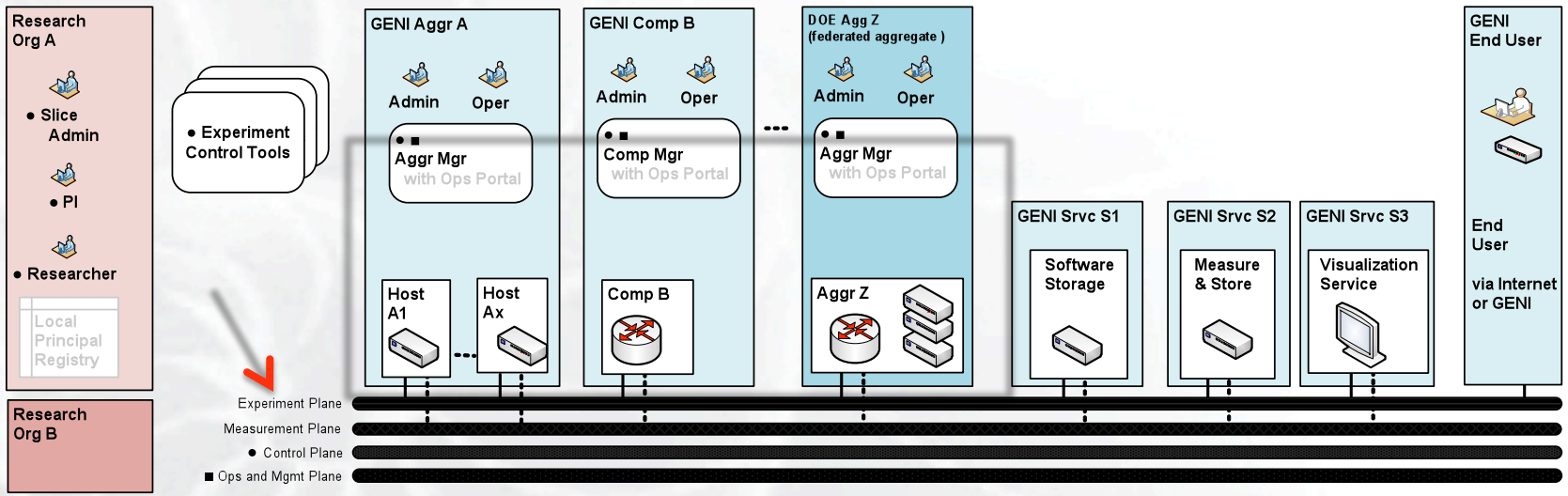
Follow-up

- Notes, slides, actions, etc will be sent to the working group mail list and posted on the wiki page: http://groups.geni.net/geni/wiki/GeniSubstrate

SWG In GENI



The **S**ubstrate **W**orking **G**roup focuses on aggregates and their interfaces, with emphasis on the experiment plane



GENI Spiral 1 Projects

Cluster A

TIED

Cluster B

PlanetLab

Enterprise GENI

GUSH Tools

Provisioning Service

Mid-Atlantic Crossroads

GpENI

SPP Overlay Hosting Nodes

Cluster C

ProtoGENI

Virtual Tunnels

CMU Testbeds

Instrumentation Tools

Measurement System

Cluster D

ORCA/BEN

Vehicular Mobile Network

Sensor/Actuator Network

Kansei Sensor Network

Cluster E

Orbit Framework

WiMAX

PICK ONE

Programmable Edge Node

Million Node GENI

Regional Opt-In

Digital Object Registry

GENI at 4yr Colleges

Embedded Real-time Measurements

Studies

GENI Meta Operations

Security Architecture

Data Plane Measurements

Optical Access Networks

Spiral-1 Substrate Projects

National Backbones

NLR

Internet2

Campus Networks

Enterprise GENI

Regional Optical Networks

GpENI

Mid-Atlantic Crossroads

ORCA/BEN

GIMS

Measurement System

Wireless and Sensor Networks

CMU Testbeds

Vehicular Mobile Network

Sensor/Actuator Network

Kansei Sensor Network

Orbit Framework

WiMAX

CPU Clusters

ProtoGENI

PlanetLab

TIED

Programmable Nodes

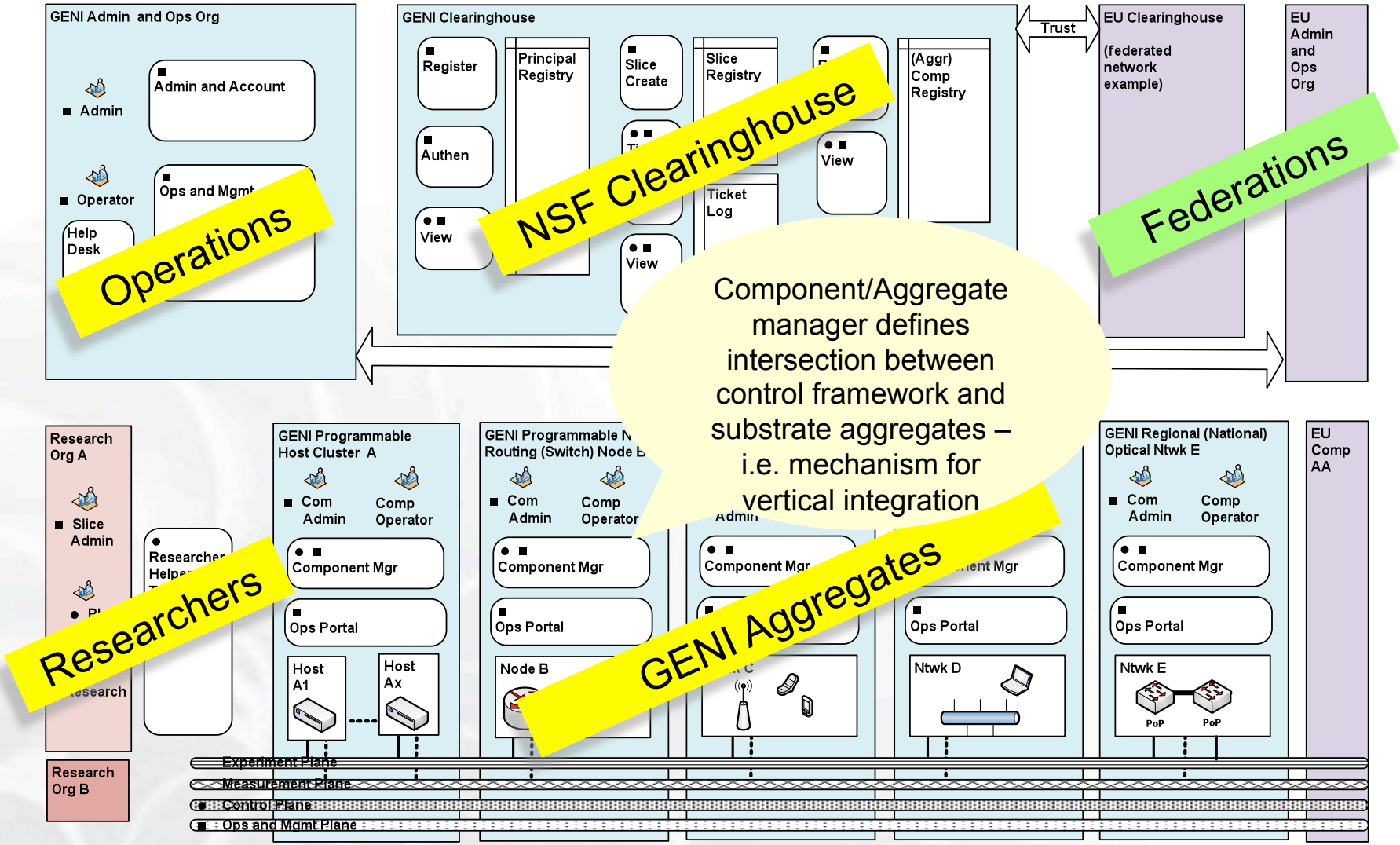
SPP Overlay Hosting Nodes

ProtoGENI

Programmable Edge Node

Integration of substrate to control framework through implementations of an aggregate manager

GENI System Decomposition



Planned Documents

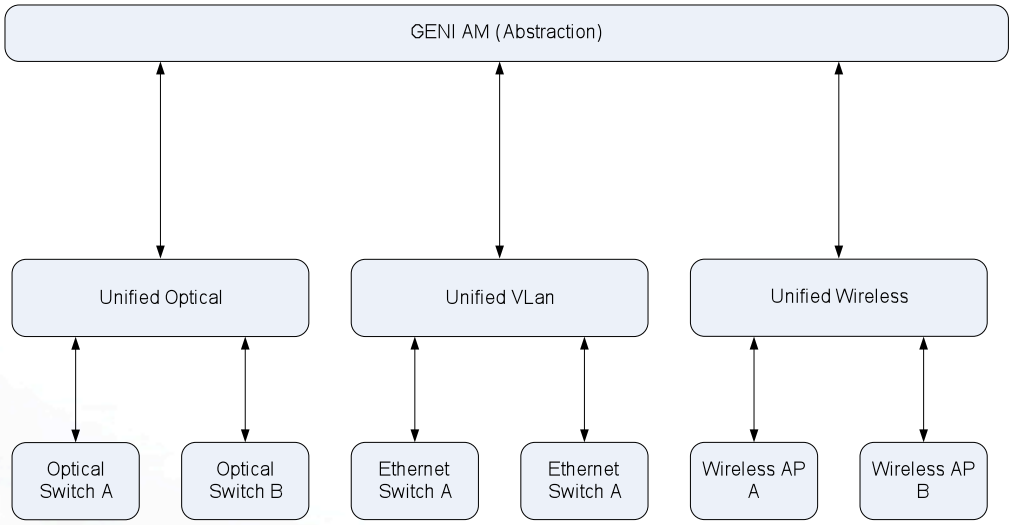
- Substrate WG Documents and Dates (Spiral 1)
  - Substrate Capabilities Summary
  - Substrate Capabilities based use-case(s)
    - Derived from Capabilities Summary
- Substrate WG Documents and Dates (GENI Design)
  - Aggregate Subsystem Technical Description
  - Aggregate ICD
    - Derived from Aggregate Subsystem Technical Description and Substrate Capabilities Summary

Spiral 1 Substrate Catalog

- Captures 6 topic areas specific to Spiral-1
  - Substrate Overview
  - GENI Resources
  - Horizontal Integration
  - Vertical Integration
  - Measurement and Instrumentation
  - Aggregate Specific Tools and Services
- Catalog location
  - http://groups.geni.net/geni/attachment/wiki/DeliverablePage/Spiral1%20substrate%20catalog.doc
- Requested Information
  - http://groups.geni.net/geni/wiki/ReqInf

GEC #4 Substrate WG Discussion

- Spiral-1 focused on “stove-piped” integration
  - Meeting their milestones
- Lower layer IF’s make-model-version dependent
  - Always some level of effort to stove-pipe
- Can a unification layer be defined?
  - Substrate type specific
  - Supports “standard” interface
    - Will this allow a broad re-use of GENI code?



3 Spiral-1 implementations (wired and wireless)
3 Generalized topics (wired, measurements, wireless)

Introduction to Control Framework Working Group

GENI Engineering Conference 4 Newcomer's Meeting Miami, FL

Harry Mussman

March 31, 2009

www.geni.net

Sponsored by the National Science Foundation

Agenda

- Introductions:
  - WG Systems Engineer
  - Control Framework WG Chairs
- Definition of the GENI Control Framework (CF) and scope of WG
- Activities in the GENI Control Framework WG
  - Spiral 1 Clusters A – E
  - CF Requirements document
- How can you understand the CFs?
- How can you participate in the WG?

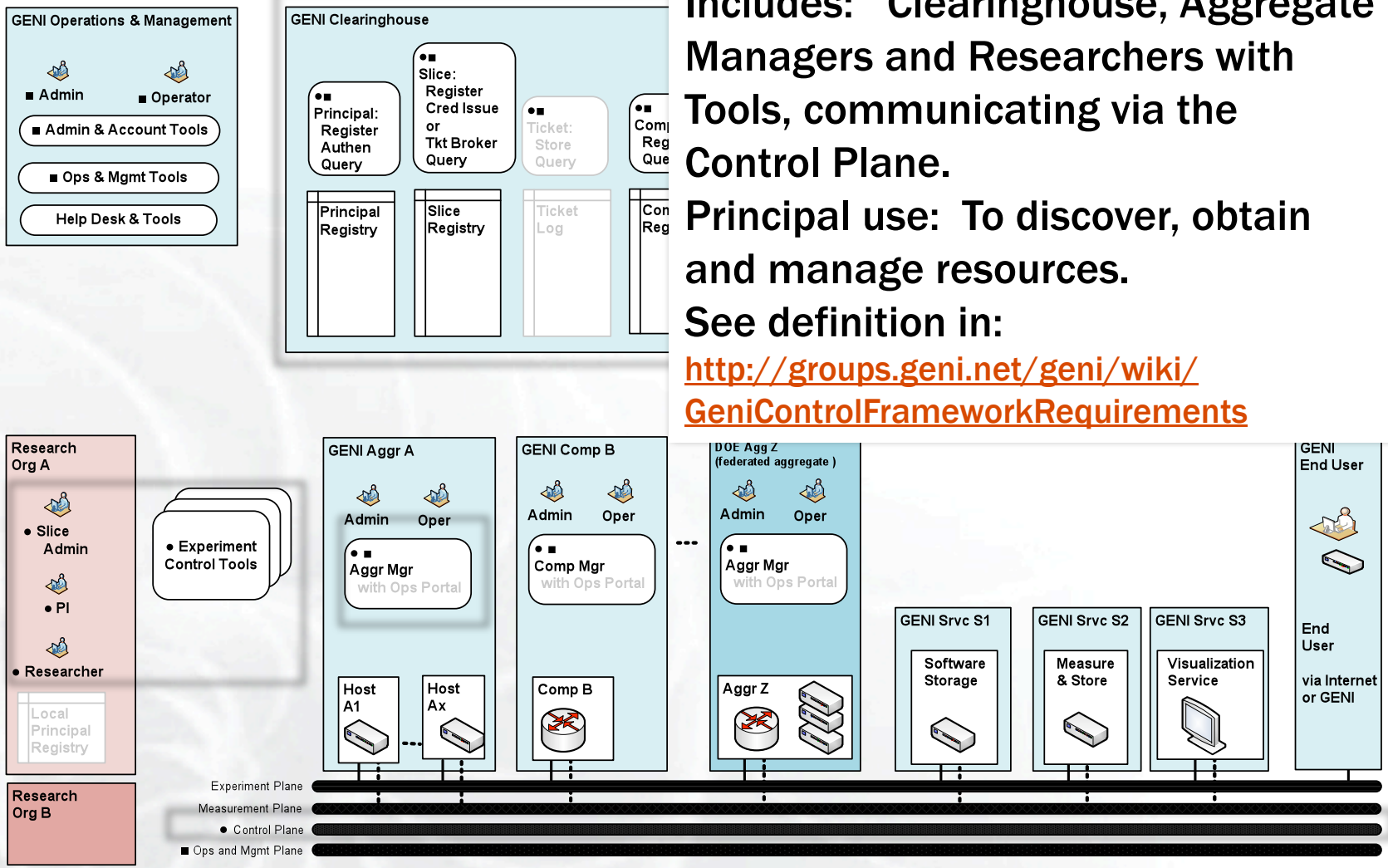
Who am I?

- Harry Mussman
  - Current: Senior Systems Engineer in the GPO at BBN
  - Last: Voice-over-IP architect at BridgePort Networks (a startup) and GTE Internetworking/Genuity
  - BSEE Univ Michigan, MSEE Northwestern Univ, PhD Stanford Univ
  - hmussman@bbn.com
- GENI roles:
  - Control Framework WG SE
  - Opt-in WG SE
  - GPO coordinator for six Spiral 1 projects

Control Framework WG Chairs

- Larry Peterson – Princeton
- John Wroclawski – USC/ISI

What is the GENI Control Framework?



Includes: Clearinghouse, Aggregate Managers and Researchers with Tools, communicating via the Control Plane.

Principal use: To discover, obtain and manage resources.

See definition in:
http://groups.geni.net/geni/wiki/GeniControlFrameworkRequirements

Scope of the Control Framework WG

- What is universal across GENI aggregates?
- How will evolution be accommodated with or without a full transition of all GENI nodes at once?
- Functions:
  - aggregate control (discovering, obtaining and managing resources)
  - slice control (interfaces and mechanisms for establishing and controlling slices)
  - access control within GENI (usage policy representation and administration mechanisms)
  - interactions external to GENI (facility federation)
  - key enablers (identity, authentication)

Activities in the Control Framework WG

- Spiral 1 control-framework clusters:
  - Cluster A: TIED (DETER) PI: John Wroclawski
  - Cluster B: PlanetLab PI: Larry Peterson
  - Cluster C: ProtoGENI (Emulab) POC: Robert Ricci
  - Cluster D: ORCA/BEN PI: Ilia Baldine
  - Cluster E: ORBIT PI: Marco Gruteser
  - Integration underway; see http://groups.geni.net/geni/wiki/SpiralOne
- CF requirements: working to define and document
- Other active topics: new interface in Cluster B; resource specifications (RSpecs); security

Spiral 1 CF Clusters

Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
1609 TIED Trial Integ Environ DETER	1600 PlanetLab	1579 ProtoGENI	1582 ORCA/ BEN	1660 ORBIT Framework
	1613 Enterprise GENI	1601 Virtual Tunnels	1599 Vehicular Mobile Network	1657 WIMAX
	1621 GUSH Tools	1646 CMU Testbeds	1602 Sense/Actuate Network	**Study All**
	1622 Provisioning Service	1642 Instrument Tools	1633 Kansei Sensor Network	1604 GENI Meta Operations
	1658 Mid-Atlantic Crossroads	1628 Measurement System		1632 Security Architecture
	1595 Great Plains Environ	1643 Programmable Edge Node		1631 Embedded Real-time Measure
	1578 Overlay Hosting Nodes			1619 Optical Access Networks

Pick One

1645 Million- Node GENI

1650 Regional Opt-In

1663 Digital Object Registry

1610 GENI at 4-Year Colleges

1653 Data Plane Measurements

CF Requirements Document

- DRAFT document published Jan 9.
  - See http://groups.geni.net/geni/wiki/GeniControlFrameworkRequirements
  - Will be used to evaluate CF designs
- CF WG conference call on Feb 25 has led to continued discussion of these topics:
  - Identity vocabulary
  - Slice controller
  - Interoperable suites
  - others
  - Next:
  - Work towards a "rough consensus"
  - Revise document and review again

How can you understand the CFs?

- Read GENI system overview for a “roadmap”
- See http://groups.geni.net/geni/wiki/GeniControl
- Read (draft) GENI CF requirements document
- Read (draft) GENI CF overview documents:
  - PlanetLab (Cluster B)
  - ProtoGENI (Cluster C)
  - ORCA (Cluster D)
  - others in preparation
- Check status of each CF project
- Talk with PIs

How can you participate in the WG?

- Check wiki for activities:
  - http://groups.geni.net/geni/wiki/GeniControl
  - See meeting announcements, notes, presentations.
  - Check work in progress, DRAFT documents, etc.
- Join the mailing list!
  - Listen, and then participate in a discussion.
  - Participate in document reviews.
  - Once you are on (any) list, you can contribute to the wiki.
- Attend meetings

Introduction to End-User Opt-In Working Group

GENI Engineering Conference 4 Newcomer's Meeting Miami, FL

Harry Mussman

March 31, 2009

www.geni.net

Sponsored by the National Science Foundation

Agenda

- Introductions:
  - WG System Engineer
  - End-User Opt-In WG Chairs
- Definition and scope of GENI End-User Opt-In
- WG Activities and Status
  - Five basic end-user opt-in uses cases have been defined.
  - Three basic capabilities have been defined.
  - Current Spiral 1 projects are including some of the required capabilities.
  - WG goal: First DRAFT of "GENI End-User Opt-In Overview" document.
- How can you participate in the WG?

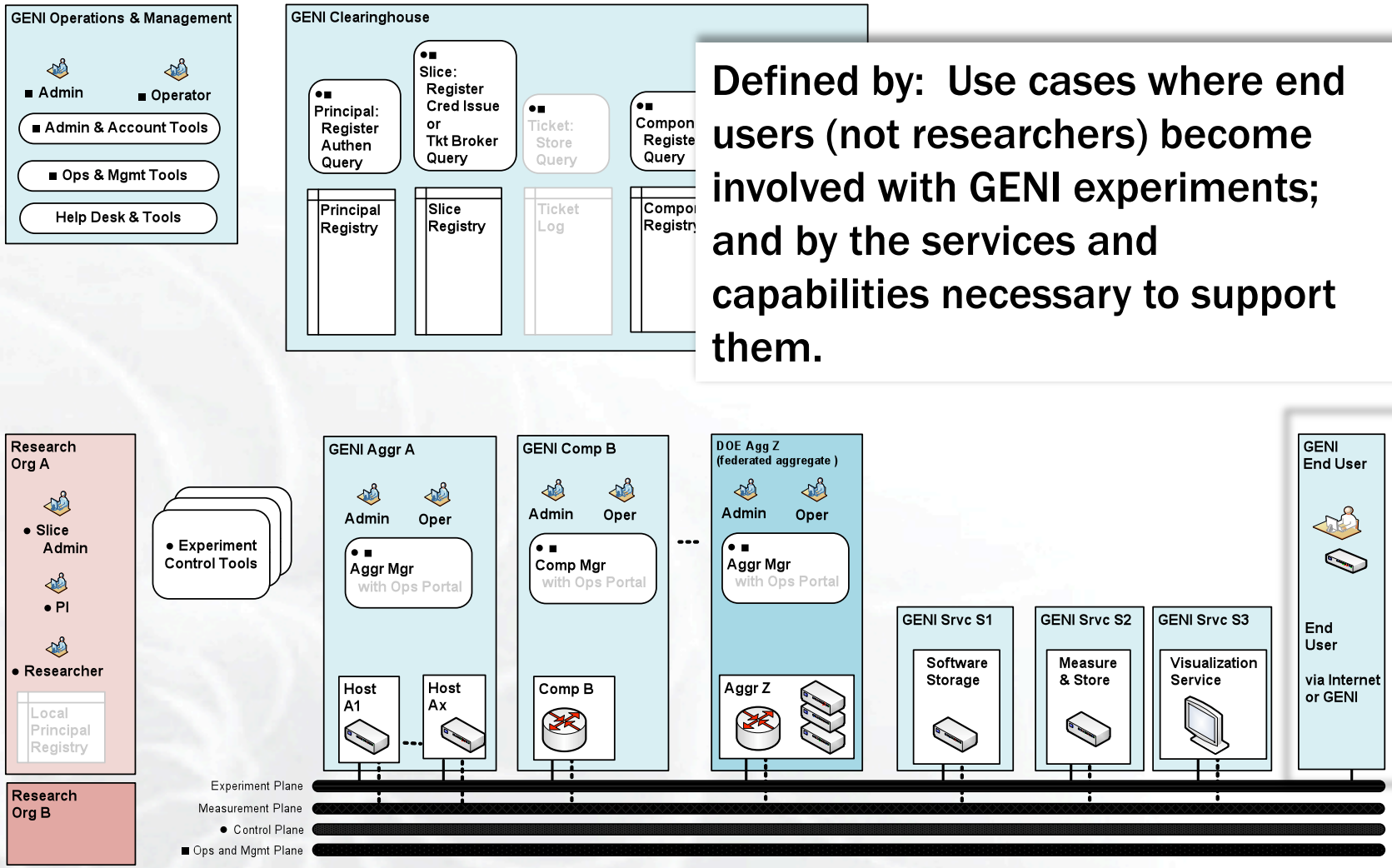
Who am I?

- Harry Mussman
  - Current: Senior Systems Engineer in the GPO at BBN
  - Last: Voice-over-IP architect at BridgePort Networks (a startup) and GTE Internetworking/Genuity
  - BSEE Univ Michigan, MSEE Northwestern Univ, PhD Stanford Univ
  - hmussman@bbn.com
- GENI roles:
  - Control Framework WG SE
  - Opt-in WG SE
  - GPO coordinator for six Spiral 1 projects

End-User Opt-In WG Chairs

- Henning Schulzrinne – Columbia
- Helen Nissenbaum – NYU

What is GENI End-User Opt-In?



Scope of the End-User Opt-In WG

- How do end-users (including Internet users) participate in GENI experiments?
- What are the various aspects including user interfaces, scheduling, debugging, measurement, archiving data, sandboxes, etc?
- What are the privacy and legal issues involved in user opt-in?

WG Activities and Status

- Five basic end-user opt-in uses cases have been defined.
- Three basic capabilities have been defined.
- Current Spiral 1 projects are including some of the required capabilities.
- WG goal: First DRAFT of “GENI End-User Opt-In Overview” document.

Required Capabilities being built into Spiral 1

- Capability 1: Gateway from GENI to another network, e.g., the Internet
  - 1601 Virtual Tunnels (Nick Feamster – Georgia Tech)
  - 1650 Regional Opt-In (Matt Mathis – PSC)
- Capability 2: Contribution (or association) of a user's node to an experiment on GENI
  - 1645 Million Node GENI (Justin Cappos – U Washington)
  - Capability 3: Gathering logs and experiment data on GENI (some possibly user-identifiable) and managing their distribution
  - 1628 Measurement System (Paul Barford – U Wisconsin)

Spiral 1 Projects with End-User Opt-In Capabilities

Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
1609 TIED Trial Integ Environ DETER	1600 PlanetLab	1579 ProtoGENI	1582 ORCA/ BEN	1660 ORBIT Framework
	1613 Enterprise GENI	1601 Virtual Tunnels	1599 Vehicular Mobile Network	1657 WIMAX
	1621 GUSH Tools	1646 CMU Testbeds	1602 Sense/Actuate Network	**Study All**
	1622 Provisioning Service	1642 Instrument Tools	1633 Kansei Sensor Network	1604 GENI Meta Operations
	1658 Mid-Atlantic Crossroads	1628 Measurement System		1632 Security Architecture
	1595 Great Plains Environ	1643 Programmable Edge Node		1631 Embedded Real-time Measure
	1578 Overlay Hosting Nodes			1619 Optical Access Networks

Pick One

1645 Million- Node GENI

1650 Regional Opt-In

1663 Digital Object Registry

1610 GENI at 4-Year Colleges

1653 Data Plane Measurements

Basic End-User Opt-In Use Cases

- Use Case 1: User opt-in to GENI experiment for service
  - See Opt-in Workshop report by Craig Partridge.
- Use Case 2: Wholesale opt-in to GENI of traffic
  - See DRAFT requirements from 1650 Regional Opt-In project (Matt Mathis – PSC).
- Use Case 3: A disruptive GENI experiment
  - Consider experience from PlanetLab by Larry Peterson - Princeton.
- Use Case 4: Opt-in of user resources to a GENI experiment
  - Studied in 1645 Million Node GENI project (Justin Cappos – U Washington).
  - Use Case 5: Gathering data involving opt-in users in a GENI experiment
  - Considered in 1628 Measurement System (Paul Barford – U Wisconsin).

Next: DRAFT Overview Document

- End-user opt-in uses cases are being refined and extended:
  - Add more detail.
  - Better understand the players, their relationships and motivations.
  - Clearly identify and define key issues.
  - Formulate proposed policies and best practices.
  - Fully specify required capabilities.
  - Reference current implementations, research and projects.
- Looking for common “policy themes”.
- Expect DRAFT document soon.

How can you participate in the WG?

- Check wiki for activities:
  - http://groups.geni.net/geni/wiki/GeniOptIn
  - See meeting announcements, notes, presentations
  - Check work in progress, DRAFT documents, etc.
- Join the mailing list!
  - Listen, and then participate in a discussion.
  - Participate in document reviews
  - Once you are on a list, you can contribute to the wiki.
- Attend meetings

Experiment Workflow and Services Working Group

GENI Engineering Conference 4
Miami, FL

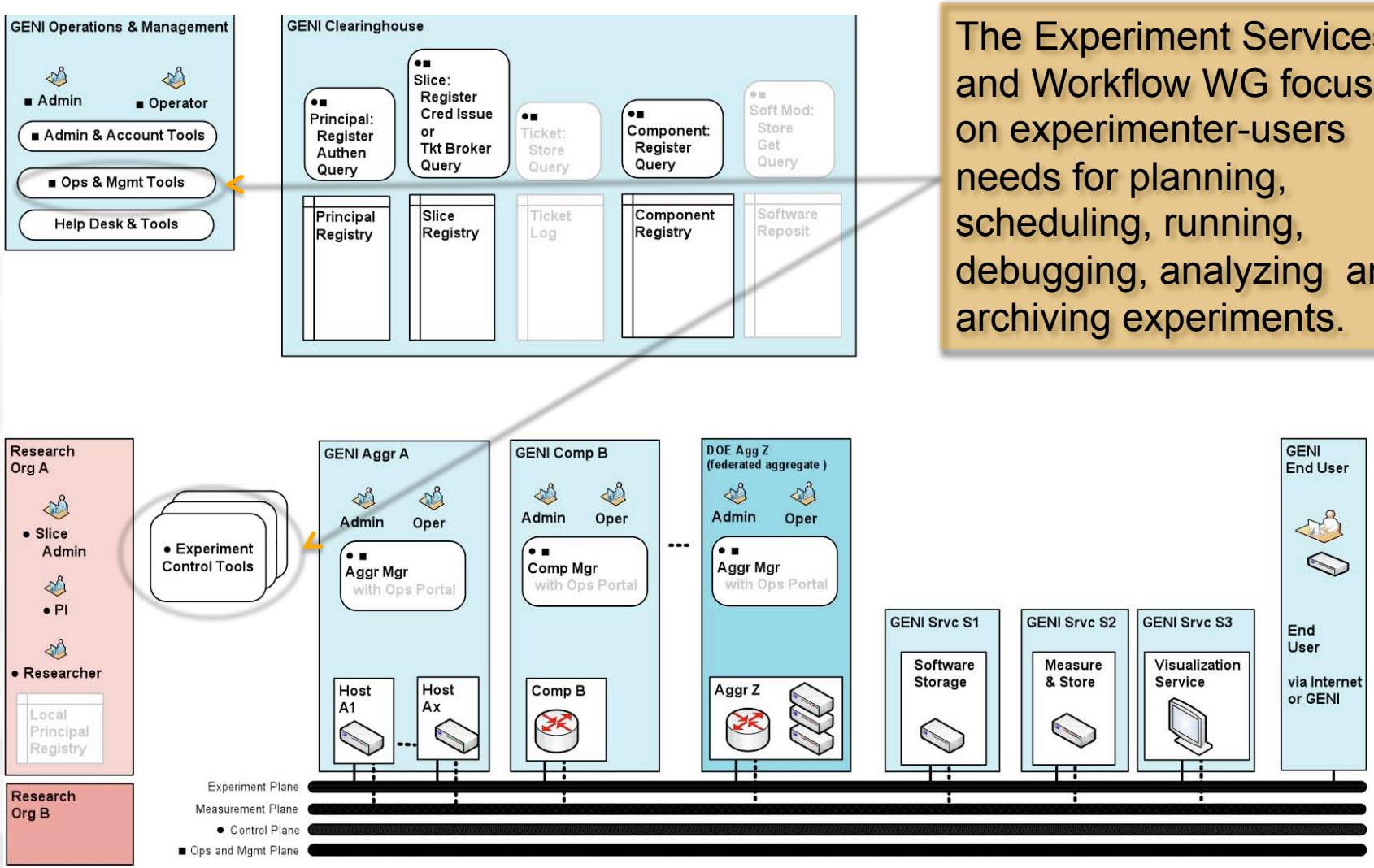
Vicraj Thomas
March 31, 2009
www.geni.net

Sponsored by the National Science Foundation

Working Group Charter

- Identify and specify tools and services needed to run experiments on GENI
  - Planning, scheduling, deploying, running, debugging, analyzing, growing/shrinking experiments
  - Collaboration
    - Multiple researchers on an experiment
    - Building on other experiments
- http://www.geni.net/wg/services-wg.html

Relationship to GENI Architecture



The Experiment Services and Workflow WG focuses on experimenter-users needs for planning, scheduling, running, debugging, analyzing and archiving experiments.

Related Spiral 1 Projects

Cluster A	Cluster B	Cluster C	Cluster D	Cluster E	
1609 TIED Trial Integ Environ DETER	1600 PlanetLab	1579 ProtoGENI	1582 ORCA/ BEN	1660 ORBIT Framework	
	1613 Enterprise GENI	1601 Virtual Tunnels	1599 Vehicular Mobile Network	1657 WIMAX	
	1621 GUSH Tools	1646 CMU Testbeds	1602 Sense/Actuate Network	**Study All**	**Pick One**
	1622 Provisioning Service	1642 Instrumentation Tools	1633 Kansei Sensor Network	1604 GENI Meta Operations	1645 Million- Node GENI
	1658 Mid-Atlantic Crossroads	1628 Measurement System		1632 Security Architecture	1650 Regional Opt-In
	1595 Great Plains Environ	1643 Programmable Edge Node		1631 Embedded Real-time Measure	1663 Digital Object Registry
	1578 Overlay Hosting Nodes			1619 Optical Access Networks	1610 GENI at 4-Year Colleges
					1653 Data Plane Measurements

Working Group Mechanics

- Chair: Prof. Jeff Chase, Duke University
- Email list to discuss topics of interest
  - Open to all
  - Subscribe at URL on previous slide
- Working Group Wiki page
  - http://groups.geni.net/geni/wiki/GeniServices
  - Any email list subscriber can contribute to wiki
- Face-to-face meetings at GECs

Who am I?

- Vicraj Thomas
  - Background in highly dependable distributed systems and networks, network security
  - Ph.D. University of Arizona, MS University of Rhode Island, B. Tech. IIT Mumbai
- GENI roles
  - Experimenter Workflow and Service WG SE
  - Security SE (with Heidi Dempsey Pitcher)
  - GPO coordinator for five Spiral 1 projects

Working Group Deliverables

- Lifecycle of a GENI Experiment
  - Document review scheduled for Fri April 17
  - http://groups.geni.net/geni/attachment/wiki/ExperimentLifecycleDocument/ExperimentLifeCycle-v01.1.pdf
- Experiment Workflow Services: Spiral 1 Capabilities
  - In Progress
- Workflow Services: Technical Requirements
  - Not started
- GENI Measurement System Architecture
  - Not started

Upcoming Events

- Experiment Services WG Meeting
  - Tomorrow (Wednesday) at 3.30pm
- Review of the Lifecycle of an Experiment Document
  - 10am ET on Friday April 17, 2009
  - Open to all: Call-in number will be emailed to WG mailing list

Lifecycle of an Experiment

- Purpose: Identify tools and services to support experimentation with GENI
  - Steps in the lifecycle of an experiment
    - From experiment planning to experiment sunsetting
  - Tools and services needed to support these steps
- Illustrated using a fictional story of an experiment that starts at a university, grows to include a industrial collaborator and opt-in users, and eventual transition to product

Introduction to GENI Integration and the Operations, Management, Integration and Security (OMIS) Working Group

GENI Engineering Conference 4
Newcomer's Meeting
Miami, FL

Heidi Picher Dempsey

March 31, 2009

www.geni.net

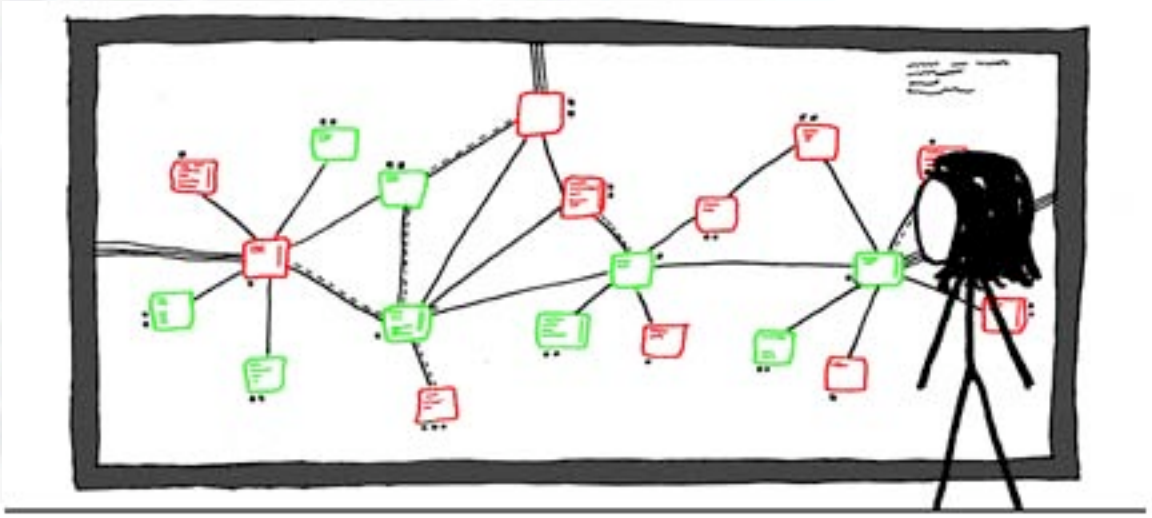
Sponsored by the National Science Foundation

Who am I (part 1)?

- hdempsey@geni.net
  - Operations Director for GENI (e.g. mailing lists, wiki, web site, demos, eventual GENI operations as it evolves)
  - geni-ops@geni.net (don't worry if your first message to this list is "held for approval"—we're trying to limit SPAM)
  - Coordinator for project leads and GPO system engineers on GENI integration milestones for each spiral (http://groups.geni.net/geni/roadmap lists all current and past-due milestones by target date for Spiral 1)
  - System Engineer for several Spiral 1 projects
  - (with Mike Patton and projects) engineer GENI connections with other networks (e.g. Internet2, NLR, regional networks, campus networks)

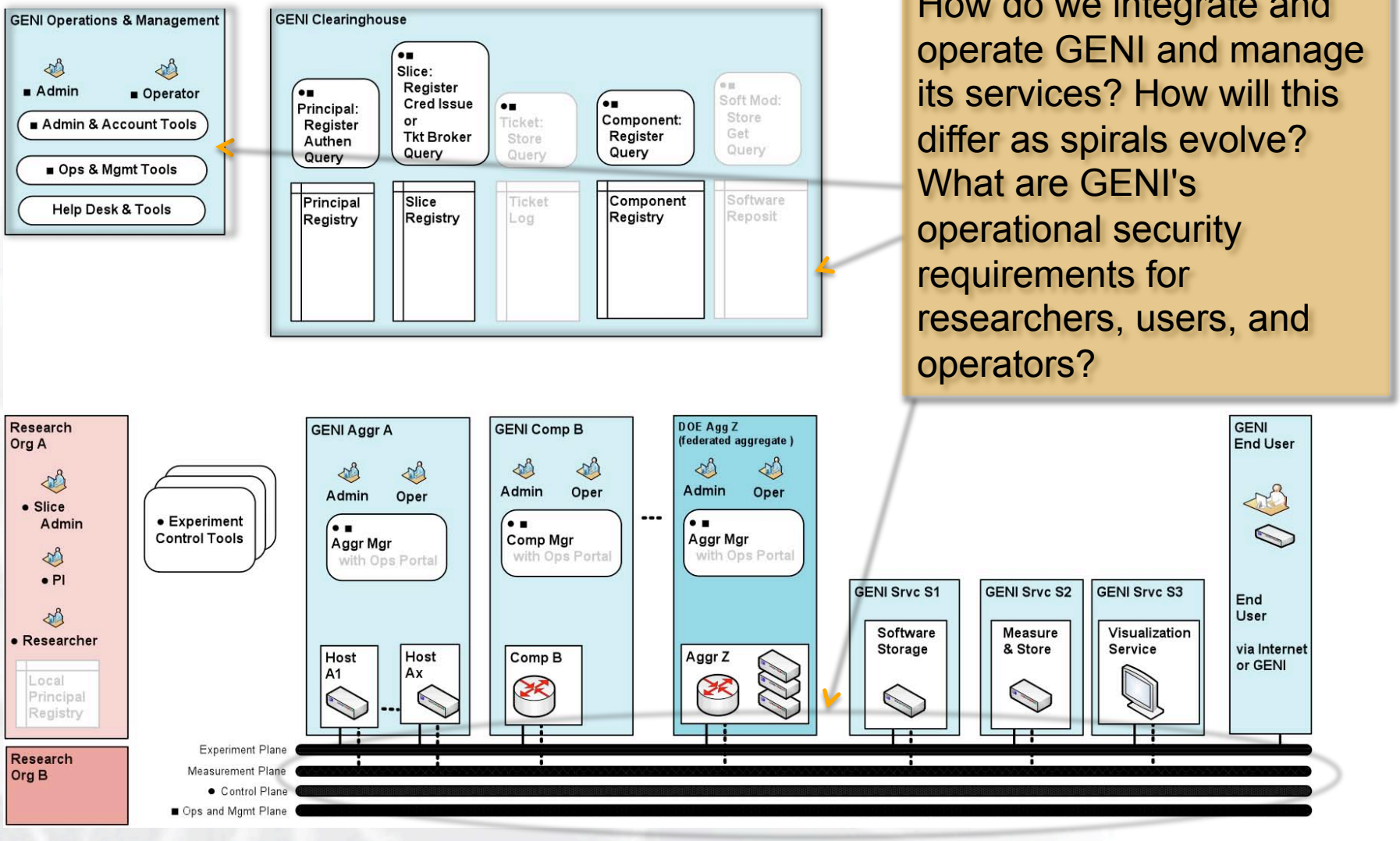
Who am I (part 2)?

- hpd@bbn.com
  - Chair of the OMIS working group (Mike Patton is the system engineer for OMIS). http://groups.geni.net/geni/wiki/GeniOmis has lots of OMIS information.
  - Advisor for several GENI interns (send resumes!)
  - GPO visitor (should we come to *your* campus?)



courtesy xkcd.com

OMIS relationship to GENI Architecture



Activities in OMIS

- Operations Framework: define and engineer high-level functions required for coordinating operations in the near-term research and prototype environment. We like use cases (http://groups.geni.net/geni/wiki/GeniOmisUseIntro) and discussions.
- Management: Data Sharing for GENI Meta Operations (http://groups.geni.net/geni/attachment/wiki/GENIMetaOps/operational_dataset_v31.pdf). We like interfaces, APIs, and data structures.
- Security: Draft Recommended Use Policy (http://groups.geni.net/geni/wiki/RUP) and Spiral 1 Draft Security Architecture (http://groups.geni.net/geni/attachment/wiki/GENISecurity/GENI-SEC-ARCH-0.4.pdf). Pay special attention to Spiral 1 action items in security draft!

But wait, you forgot the "I" in OMIS!

Cluster A

1609 TIED Trial Integ Environ DETER

Cluster B

1600 PlanetLab

1613 Enterprise GENI

1621 GUSH Tools

1622 Provisioning Service

1658 Mid-Atlantic Crossroads

1595 Great Plains Environ

1578 Overlay Hosting Nodes

Cluster C

1579 ProtoGENI

1601 Virtual Tunnels

1646 CMU Testbeds

1642 Instrument Tools

1628 Measurement System

1643 Programmable Edge Node

Cluster D

1582 ORCA/ BEN

1599 Vehicular Mobile Network

1602 Sense/Actuate Network

1633 Kansei Sensor Network

Cluster E

1660 ORBIT Framework

1657 WIMAX

Study All

1604 GENI Meta Operations

1632 Security Architecture

1631 Embedded Real-time Measure

1619 Optical Access Networks

Pick One

1645 Million- Node GENI

1650 Regional Opt-In

1663 Digital Object Registry

1610 GENI at 4-Year Colleges

1653 Data Plane Measurements

No we didn't , it's a group effort!

- Spiral 1 GENI project pages explain how integration milestones relate (http://groups.geni.net/geni/wiki/SpiralOne). (If they don't, they should—complain!)*
- Funded projects' contacts, schedules, links to other sites, and quarterly reports all available on wiki
- GENI tickets show progress, allow projects to request actions from each other and GPO, escalate issues (Tickets by milestone report http://groups.geni.net/geni/report/3).
- All working group mailing list participants get wiki (and ticket) write access. (Sign up at http://lists.geni.net/mailman/listinfo)
- GPO also tracks all this as part of evaluating, funding, and continuing GENI projects.

* they also tell you what's wrong with slide 6

Isn't that a lot of overlap?

- That's why OMIS is a nosey group. ;-)
- Lots of projects started Spiral 1 doing similar but related things in different places (clusters). Most plan to show well-integrated prototypes by September 2009.
- "Horizontal" cuts (e.g. substrates, routing, data planes) overlap by nature.
- "Vertical" cuts, e.g. control interactions between clearinghouses and aggregates may differ greatly in implementation, but carry out many of the same high-level functions.
- GENI "Meta Operations" is in early definition stage, but is likely to create windows into this kind of GENI data where there is overlap and interest (well, maybe skylights for the vertical windows).

GENI wiki examples (look for yourself)